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# CLEAN AIR ACT AMENDMENTS OF 1989

## HEARINGS

BEFORE THE

## SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION

OF THE

## COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

TO CONSIDER THE RESULTS OF THE NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM

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OCTOBER 5, 1989

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**PART 6**

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# CLEAN AIR ACT AMENDMENTS OF 1989

## National Acid Precipitation Assessment Program

THURSDAY, OCTOBER 5, 1989

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 10:04 a.m., in room 406, Dirksen Senate Office Building, Hon. Max Baucus (chairman of the subcommittee) presiding.

Present: Senators Baucus, Chafee, and Moynihan.

### OPENING STATEMENT OF HON. MAX BAUCUS, U.S. SENATOR FROM THE STATE OF MONTANA

Senator BAUCUS. The subcommittee will come to order. Good morning, and welcome to all our witnesses and other guests who have come here this morning.

We have called this hearing this morning to consider the results of the National Acid Precipitation Assessment Program, commonly called NAPAP, which the Congress created in 1980 under P.L. 96-294.

We have six witnesses with us this morning. The first panel will consist of Federal Government officials connected with NAPAP: Dr. James Mahoney, Director of NAPAP; Mr. William Rosenberg, Assistant Administrator for Air and Radiation at the Environmental Protection Agency; and Dr. Courtney Riordan, Director of the Office of Environmental Processes and Effects Research at USEPA.

The second panel will consist of Dr. Milton Russell, Chairman of the NAPAP Oversight Task Force at the University of Tennessee, who is a collaborating scientist at Oak Ridge National Laboratory; Mr. Walter Kretser, Project Director, New York State Adirondack Lake Survey Corporation; and Dr. George Hidy, Technical Vice-President for Environmental Affairs at EPRI, the Electric Power Research Institute at Palo Alto, California.

Actually, I had not expected to be able to be here this morning, and I had asked my good friend and colleague, Senator Moynihan, to stand in for me. So let me turn the hearing over to the Senator from New York in honor of his initiation of this idea and in honor of his efforts to help make this come to a conclusion.

## OPENING STATEMENT OF HON. DANIEL PATRICK MOYNIHAN, U.S. SENATOR FROM THE STATE OF NEW YORK

Senator MOYNIHAN. Mr. Chairman, this is your legislation, and you are bringing it along brilliantly and successfully—something that, for a whole decade, eluded the Committee and the Congress.

Let me just say I hope that we can look upon this work we are going to hear of today not as threatening, but as confirming. I do believe it is the case—and I'd welcome Mr. Rosenberg's judgment on that—that in the history of environmental legislation in our committee, there has never before been a study that has lasted this long. This was introduced in this committee 10 years ago. I have grown gray. We are more mature, no doubt.

I see there are members of the press present. Let me just say that, in the main, the first response of societies over time to scientific findings is one of fear and rejection. I am glad to see some people writing that down—fear and rejection.

Remember, the first thing you are inclined to do is nothing. Isn't that wonderful? We've discovered something new. But the reaction, isn't that heretical? You've said something that is wrong. And sometimes it takes a very long while to get settled what is right, and the history of society is, in the end, that facts tends to assert themselves, but not before a lot of people have been burned at the stake. And it is awfully hard to get them back—but there is another matter.

I mean to say, Mr. Chairman, that it will be a measure of the maturity of the environmental movement and of the Committee on Environment and Public Works and the Environmental Protection Agency that we look at this data and inform our legislative drafting with the data. It is a nice characteristic of science that it is a universal language. I am going to particularly ask that we have our Canadian friends look at it. We are going to have a big conference this winter. Doctor Mahoney is nodding yes.

I think we now know more about this than anybody anywhere, don't we? I don't think that anybody—the Europeans don't have this kind of data neither do the Canadians. It is hard for them to do because acidic deposition comes at them from us. But this is no ordinary moment, and I'm pleased to see so many persons here to witness it. Thank you for the opportunity to make these remarks.

Senator BAUCUS. Thank you very much, Senator.

Our first panel consists of: Doctor Mahoney, who is director of the NAPAP Program; Mr. Bill Rosenberg, EPA; and Doctor Courtney Riordan, who is the Director of the Office of Environmental Processes and Effects Research at the U.S. Environmental Protection Agency. He is accompanied by Bruce Jordan, who is the chief of the Ambient Standards Branch of the Office of Air Quality, EPA.

Who wants to begin? Bill, why don't you begin?

## STATEMENT OF HON. WILLIAM ROSENBERG, ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION, ENVIRONMENTAL PROTECTION AGENCY

Mr. ROSENBERG. Thank you, Mr. Chairman and Senator Moynihan.

My colleagues and I from the EPA are pleased to be here to discuss the scientific understanding of acid deposition and title V of the Clean Air Act Amendments of 1989.

I am not a scientist, and I am, therefore, delighted to be joined by Doctor Mahoney, who is Director of the NAPAP program who has done such an outstanding job in leading that effort. And with me today from EPA are Doctor Riordan and Mr. Jordan, who you introduced.

Doctor Riordan is here to answer any questions on acid deposition as it relates to human health and visibility issues that were beyond the NAPAP study.

And I will be available to answer any questions that you may have regarding the Clean Air Act Amendments submitted by the President.

NAPAP was an ambitious undertaking on the causes and effects of acid deposition. The work conducted under the auspices of NAPAP has made very significant contributions not only regarding our understanding of acid deposition, but also to our fundamental knowledge about our ecosystems that will help us deal with this and other environmental problems in the future.

Doctor Mahoney and the NAPAP staff are to be commended for their efforts in coordinating the array of studies on complex issues such as watershed responses to acidification stresses, how forests grow and respond to different stresses, and projections of future effects of acid deposition and emission reductions.

The NAPAP member agencies, including EPA and the Departments of Energy, Commerce, Agriculture, and Interior, are also to be commended for working together on these important and complex issues in order to further our knowledge of atmospheric pollution and its consequences.

The work conducted under the auspices of NAPAP, as well as other scientific research, indicated to us the importance of controlling the acid rain problem. In general, these various studies and surveys show that acid deposition has created stresses on the environment that need to be addressed.

Perhaps the most compelling scientific indicator is the documentation of the status of lakes and streams conducted under the auspices of NAPAP which demonstrated how many lakes and streams were currently acidic and sensitive to episodic acidification that could adversely affect the fish in our surface waters.

Research on the chemical status of surface waters prior to the widespread burning of fossil fuels in the production of energy established the link between manmade emissions and surface water acidification. Research also indicates that acid deposition could affect high elevation forests that are national treasures deserving protection.

In addition, we see the same chemicals that cause acid deposition adversely affecting visibility in our national parks, human health through the breathing of acidic aerosols, and materials such as statues and buildings throughout the eastern half of the U.S.

Science has not precisely made all the definitive linkages between acid deposition and damage to human health and the environment, nor will it provide us with some kind of magic solution to the problem. What science can do is provide the information base

that points policy makers in the right direction, without necessarily providing all of the information that tells them exactly how far to go or how to get there.

Policy makers in the Administration and in the Congress must make choices on imperfect information which exists in almost all cases, even after the expenditure of large sums in research.

In the case of acid rain, the link between deposition and surface water acidification is clearly established. The link between sulfates and visibility degradation is also established. And, in the case of the health risk from acid aerosols, while the link is not as clearly established, it cannot be ignored.

In sum, science points in the direction of controlling acid deposition through reductions in the emissions of sulfur dioxide and nitrogen oxides.

We interpret the currently available information on the effects of acid deposition to mean that we should seek as large a reduction in the emissions of sulfur dioxide as reasonably possible, in as short a time period as possible, taking into consideration various factors. These factors include scientific knowledge, cost effectiveness, fairness, and the state of technology control development.

For example, science alone did not produce the President's goal and the Congressional goal of a 10 million ton reduction by the year 2000 in emissions of sulfur dioxide, and to keep that reduction once it is achieved. But science played an important role in the decision to seek such a reduction. This goal is significant, it is achievable, and it will be beneficial for the environment.

Mr. Chairman, thank you for the opportunity to appear today.

I would now like to introduce Doctor Riordan, who will briefly discuss EPA's contributions to NAPAP. And then I would assume Doctor Mahoney will follow him.

Senator BAUCUS. Before we do that, Mr. Rosenberg, I'd like Doctor Mahoney to give his testimony. He's been the director of the program and, frankly, I was remiss in not having him give his testimony first.

I'd like you to go ahead, Doctor Mahoney. You're the head man here.

## STATEMENT OF JAMES R. MAHONEY, DIRECTOR, NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM

Dr. MAHONEY. Thank you, Mr. Chairman and Senator Moynihan. I note the responsibility that is involved in reporting on the results of a $500 million research effort. On your characterization, Mr. Chairman, as head man, I'll try to quickly respond to your challenge.

In starting, of course, I want to thank you for your invitation to express our findings to you in this context.

I would note on one matter that Senator Moynihan spoke about, I have just returned from meetings on Monday and Tuesday of this week representing the Government of the United States and the people of the country in Germany with our scientific and government agency colleagues, principally from Germany, but really from all of Western and much of Eastern Europe.

I want to report to you in this context that it is delightful to see the level to which our European colleagues look at the research and assessment accomplishments on the U.S. side as a leadership set of accomplishments and how much they will be playing a key role in the major, international conference we will be conducting next February concerning our research findings to date.

Now, going along with my specific testimony, my intention is to describe much of the current scientific information about acidic deposition effects and some of the key findings which have come from recently completed projections on future surface water chemistry at different acidic deposition levels.

NAPAP is preparing a broad set of projections to compare the range of control costs and the environmental benefits associated with various levels, schedules, and geographic patterns of emission controls.

While many of these projections are not yet available—they are what we are doing currently—I want to give you, at the outset, the sense of my personal, scientific judgment.

As a reference point for these comments, I note that you are considering several suggestions for sulfur dioxide emission reductions of 10 million short tons below the 1980 levels. In my view, emission reductions in this range would benefit aquatic resources and would mitigate other environmental effects caused by acidic deposition and its precursor gases, as described further in my testimony and in other NAPAP reports.

To preserve NAPAP's credibility as a technical fact finder, as opposed to an advocate for a specific position, we do not make recommendations about a precise control level. We limit our efforts to providing the Congress and the Nation with the best, thoughtfully-reviewed, scientific and technological information that we can. We recognize that you in the Congress, together with the President and his policy officials, including Mr. Rosenberg, must ultimately make the decisions about levels of control reflecting both scientific information and many other concerns which go into that equation.

We have established two guidelines for the kinds of information that we report. First, it is our goal to provide the best technical conclusions supportable by evidence. In that regard, we rely heavily upon scientific peer review, by review of all of the relevant Federal Government agencies—and I'd note, parenthetically, that this has been a major strength of the program, this sense of continuous development and review of information involving the various agencies and their missions over the life of NAPAP. We also rely heavily on broad review of the entire scientific and interest communities, including the environmental groups, our Canadian neighbors, and the broad energy sector and business communities, as well.

In a word, our attempt is to assure that all that we report is written out carefully and subjected to thoughtful challenge appropriate for the scientific method so that what we deliver is the best view that we can express.

The second of our two guidelines, along with giving the best conclusions we can supportable by evidence, is to describe the confidence levels and the uncertainties associated with this work. The purpose of that is not to let uncertainty be a mask for giving our

best view; but, rather, to be cautious so that we don't overstate our case.

Now, the remainder of my testimony, which is very long in written form, I want to characterize briefly—especially paying attention for a brief time to key findings areas.

All together, the testimony deals with three topics.

Senator BAUCUS. Yes. This is important, Doctor Mahoney, so I'll give you a few more minutes. You can summarize, and I'll give you ample time.

Dr. MAHONEY. Thank you, Mr. Chairman. I'll do that, but still try to be reasonably brief about it all and, of course, be open for questions as appropriate.

There are three areas all together. The first will consume nearly all of my verbal statement. I do want to talk about our knowledge about effects. Second, we have prepared—and it appears in my statement—an extensive listing of the accomplishments of the NAPAP research over the years. Third, in your invitation you asked us for recommendations about future data gathering needs, and I'll speak about that in closing.

Now, in the effects areas, I will start my comments with a reference to aquatic ecosystems. I'd note that of all of the effects areas, of interest to us, that which has driven us most strongly has been our concern about lakes and streams—basically the surface waters and watersheds—in various parts of the country but, in particular, in the eastern part of the country.

In order to convey complicated information in fairly brief form, I will pose and comment about a few specific questions.

The first question: are there acidic lakes and streams in the United States, regardless of the cause of the acidity?

The answer is: of course, yes. Substantial work has been done through the national surface water surveys conducted by NAPAP and its member agencies—in particular, EPA—to develop a solid atlas of the condition of surface water acidity during the last several years.

The regions for these studies, which are those regions of special concern, are indicated in the chart which is facing the panel and are also copied in the testimony statement. These were selected because these are the areas which could potentially experience acidification problems, by our best judgment, in the United States.

Now, the chart which my colleague will put up on a separate easel, summarizes the overview chemical data from the survey. Please note, that while we speak about water chemistry, the major concern centers on biological effects or the continued presence of fish and of robust life system in lakes and streams.

Focusing on one of the columns in this chart, the column for acid neutralizing capacity less than or equal to zero, we note that our summary finding is that 5 percent of the lakes in the northeast are currently acidic; that is, they have no buffering capacity, as defined. Of this 5 percent average in the northeast, the range runs from a high of 11 percent in the Adirondack Region in New York to a low of approximately 1 percent in Maine.

Acidic lakes have also been found in the Michigan peninsula and northern central Wisconsin.

The highest percentage of acidic lakes found in the surveys have been in Florida, where we know that conditions other than acidic deposition are major contributors to the acidity of surface waters in Florida.

We believe that many of the northeastern acidic lakes— in Pennsylvania, New York, and New England, in particular, and somewhat in other areas—have been caused by acidic deposition. In other regions—in particular, Florida and the upper midwest, which have some populations of acidic lakes—other causes are known to be important.

Now, the next chart provides similar information for streams studied in the eastern part of the United States. The chart depicts information on the percentages of acidic stream reaches at various eastern sites. And we note here that, currently, amounts ranging between 0 percent—that is, no acidity in some areas—up to 7 percent of streams are found to be acidic. Again, a special large number is found for the Florida case. About 12 percent of the stream reaches in Florida are currently acidic. But, again, we note that decaying organic matter in the lake influences these Florida watersheds.

Obviously, a matter of great concern is the question of future projections. The next chart—which is table four in the testimony—indicates our best estimates for the acidic conditions of lakes in the northeast. You'll note from this chart, if there were no change in deposition from current levels, we would expect that in the northeast the chemical status of the lakes would stay approximately the same over the next 50 years. On the other hand, if there were approximately a 30 percent reduction in the deposition in the northeast, we would expect almost half of the currently acidic lakes to recover during that 50-year period. Many of them would begin their recovery within 10 to 20 years.

So to get a sense of overview, we are looking at a time frame of beginning recovery with reduced deposition in the northeast case on a time scale of 10 to 20 years. But it will take 50 years or longer to reach even roughly the midpoint of the recovery.

I must note before finishing that these comments, our best modeling studies show that even with reduced deposition, the recovery may be, in a sense, painful. We may find similar or even higher acidic levels for many years during the early part of the recovery, because of some of the complexities of the watershed conditions.

That has a practical implication. We will begin recovery when deposition is decreased; however, it is important that we advise you that we cannot expect to see, through natural conditions, a repopulation of fish in the affected lakes any time in the next 20 years or beyond through emission reduction, alone.

Insofar as there is an interest in having restored fish viability in the 10 or more percent of the lakes in the Adirondacks, for example, where it no longer exists, in addition to emission reductions, or whether there were such reductions or not, other intervention would be required such as liming and stocking of such watersheds and lakes as you would want to see restored to recreational use where they are not now in such use.

Senator MOYNIHAN. Mr. Chairman, can we hold it there for just a minute?

This is your finding in terms of judgments about legislation. This is the finding right here. I think if we could just stay a little bit within the time limit?

I think you used the phrase somewhere that the lakes in the northeast are in a steady state. Is that right?

Dr. MAHONEY. Yes, I did, Senator. That's in the testimony. I don't think I said it right now.

Senator MOYNIHAN. In your testimony?

Dr. MAHONEY. Right.

Senator MOYNIHAN. Now, what does steady state mean? How should laymen think of steady state?

Dr. MAHONEY. For this purpose, what steady state means—and it refers specifically to sulfur inputs, not to nitrogen inputs, I might mention, is that the amount of sulfur species—the sulfate aerosols—entering the watershed through deposition is approximately equal to the amount of such sulfates leaving the watershed through runoff. In other words, the whole watershed and its soils are not saturated with sulfur so that no more will be retained.

This means if there is a reduction in deposition levels, then in the early years after such reduction the whole soil and watershed system must find a new equilibrium level, and those soils will bleed out the sulfur which has accumulated for some long time.

Senator MOYNIHAN. I was surprised by the word "saturated." Is that what you find? It could just be that what is leaving the system is equal to what is coming into the system, without the system having reached some total capacity. Saturated suggests that you could not get any more even if you tried. Is that what you really mean? Or do you just mean input and outgo——

Dr. MAHONEY. What you're saying, Senator, is what we do mean. At least without disturbing the soil and somehow simply packing it with chemical sulfur, following the natural processes we see, the whole system and the soils have absorbed the sulfur that they are able to, and they won't absorb more. Whereas, by comparison, throughout the rest of the east that is not true.

Senator MOYNIHAN. So supposing we doubled the acid deposition? Would that have any consequence?

Dr. MAHONEY. It would have some consequence, but, as a matter of——

Senator MOYNIHAN. Not much?

Dr. MAHONEY. But not much. In fact, the situation for the northeast is that it is, in fact, not very sensitive to the deposition level. We have a percentage of acidic lakes, and no matter what we do over the next century except for restoring them one at a time through liming, little is going to change that quickly.

Senator MOYNIHAN. Over the next century? So let's say we decided to get the most sulfurous coal conceivable out of West Virginia and Ohio and used nothing—took all the scrubbers off and just banged away, that the present 10 percent of the lakes would remain at an unacceptable acidic content, and the rest would remain okay?

Dr. MAHONEY. That percentage, Senator, would increase, by my best estimate, slightly. As compared to 10, it might be 11 or 12. There would be a number of other adverse effects from such emission increases, of course.

Senator MOYNIHAN. I'm just trying to get a bearing.

Dr. MAHONEY. Sure.

Senator MOYNIHAN. We are not dealing with a tender, sensitive, young organism that can change its condition. These are old, tough mountains. I'm just trying to find out what you're saying.

Dr. MAHONEY. Well——

Senator MOYNIHAN. Doctor Riordan is very——

Mr. RIORDAN. Jim, I think that the steady state situation wouldn't change, but I think that you'd have a lot more sulfur coming down in deposition, and much higher sulfur concentrations in the surface water, which I believe would lead to a marked increase in the number of acidic lakes were we to increase deposition. Were we to double the levels of deposition, I think you'd see a drastic increase in——

Senator MOYNIHAN. Doctor, I was just saying that for purposes of taking the worst possible case.

Mr. RIORDAN. Correct me if I'm wrong, Jim, but I think that the steady state has to do with simply the mobility of sulfur through the watershed, but you would have a lot more sulfur.

Senator MOYNIHAN. Okay. Fine. We are not going to take the scrubbers off, and so forth. We are not going to double. But if we did double, we might go from 10 to 11 percent?

Mr. RIORDAN. No. I think you'd go from 10 to a lot more than——

Senator MOYNIHAN. Maybe 20?

Mr. RIORDAN. Probably.

Senator MOYNIHAN. Ten to twenty?

Mr. RIORDAN. Maybe we could look at the numbers, if we could put up the earlier slide.

What we talk about are lakes that are very sensitive that have alkalinities in the range from 0 to 50 micro-equivalents per liter. If we look at the lake survey——

Senator MOYNIHAN. Tell us what table we're on.

Dr. MAHONEY. Chart five, table four.

Senator MOYNIHAN. Okay.

Well, the chairman is not going to have this much time. What do you say we——

Senator BAUCUS. Actually, why don't you continue your testimony? We can get back to this point on steady state and the definition.

Senator MOYNIHAN. Steady state is that no matter what legislation we pass, about 10 percent of the lakes are going to be acidic beyond the lifetime of anybody in this room.

Senator BAUCUS. I don't think that's accurate.

Mr. RIORDAN. It's not accurate, Senator. No.

Senator BAUCUS. It is not accurate.

Senator MOYNIHAN. What is accurate?

Senator BAUCUS. Well, I don't know what is accurate, but I know that is not accurate.

You're right. We have a time constraint. I'd like, frankly, for Doctor Mahoney to continue his prepared testimony.

Go ahead, please.

Dr. MAHONEY. Fine. We'll do that and, I'm sure, return to this issue.

The last of the charts—and I'll ask my colleague now to put table five back up. I want to comment on the situation of the streams in the southern Blue Ridge area.

Here the projections currently available are that if the present deposition levels were to continue for the next 50 years, we have a situation where now there are no acidic streams in the southern Blue Ridge area.

Senator BAUCUS. When you say deposition levels continue, you mean the rate of deposition?

Dr. MAHONEY. Yes. If there were no changes in emissions. For example, if our Nation continued with its current level of control.

Senator BAUCUS. Thank you.

Dr. MAHONEY. Over the period of the next 50 years, where there are no streams in the region currently acidic, we would have 20 percent of the stream lengths in the southern Blue Ridge area becoming acidic over those 50 years.

Here we have the kind of comparison that Senator Moynihan was asking about a minute ago. If we had a 20 percent increase in deposition, the model projects that the number or the percentage of acidic streams would be 12 percent, as compared to the 10 percent acidity that would occur under current deposition levels.

The interpretation of this, in both cases: we will have acidic streams in the southeast area if we don't reduce deposition. And so I want to be clear about that.

Senator MOYNIHAN. If you do, how few streams will you have?

Dr. MAHONEY. How few, Senator?

Senator MOYNIHAN. Yes. What number? What proportion? When?

Dr. MAHONEY. What we indicate in table five here is that at present deposition levels, without any different emission controls, we anticipate 10 percent of the streams in the south over 50 years.

Senator MOYNIHAN. And if you cut it by 10 million tons, what will happen?

Dr. MAHONEY. We don't have that case calculated yet, so I can't give you a sound answer to that, yet, Senator.

Senator MOYNIHAN. I guess I'm trying to point out, Mr. Chairman, that the best we can tell from this data is that we have fairly sticky numbers here. An increase might go from 10 to 12 or 10 to 7.

Dr. MAHONEY. Well, you've heard two views about that. It might be from 10 to 12 or 10 to 20. I think we have to——

Senator MOYNIHAN. But not 10 to 50.

Senator BAUCUS. What is also the confidence factor, which I suspect is also debatable?

Dr. MAHONEY. Yes. We have put on these charts the confidence limits based upon the currently available information in the model projections. I think I'd simply note the current confidence limits are larger than the projections of change, themselves. This doesn't mean that we discard our ideas about change. It is, instead, a measure of the difficulty of getting the science in these very complicated watersheds correct.

Going back to a summary view of that, we're not at all saying that it doesn't make any difference what emission level we have. What we are saying is that it is a devilishly difficult job to know just what benefit we will get from this. But our best estimates are

that we won't really measure—certainly in terms of observed fish population—measured differences over the next 10 or 20 years; but we will, in the long term. We have to get started on the emission reductions if these systems are going to come around in time.

I think that is the sense of the finding. We have a set of acidic waters, and they will begin to improve or will begin to reduce their stress level only when the emission level is changed. And we should not assume that we will find major marked differences in the next few years. It will take a few decades.

Senator BAUCUS. While I have you here, I thought I heard you say that if there are reductions in deposition that, paradoxically, there might be a slight increase in what?

Senator MOYNIHAN. It gets worse before it gets better.

Senator BAUCUS. Yes. It gets worse before it gets better.

Dr. MAHONEY. The point is that the models would show that in some cases.

Senator BAUCUS. Why?

Dr. MAHONEY. Because when we start reducing deposition the chemical systems tend to look for other balancing elements, and this may include the release of some of the organic acids which come from decaying natural material—vegetation and forests—in the same watershed.

Senator BAUCUS. Is your confidence of this phenomenon equal to your confidence level in the other conclusions you have enumerated?

Dr. MAHONEY. I would say, as a general observation, yes. The point is, we see this in the individual model runs.

Senator BAUCUS. Doctor Riordan, your testimony, please?

**STATEMENT OF COURTNEY RIORDAN, DIRECTOR, OFFICE OF ENVIRONMENTAL PROCESSES AND EFFECTS RESEARCH, ENVIRONMENTAL PROTECTION AGENCY ACCOMPANIED BY MR. BRUCE JORDAN, CHIEF, AMBIENT STANDARDS BRANCH, OFFICE OF AIR QUALITY**

Mr. RIORDAN. I have written testimony, Senator.

Senator BAUCUS. If you could summarize it.

Mr. RIORDAN. I would like to submit that for the record and briefly summarize.

Senator BAUCUS. All statements will be included in the record. Please summarize your prepared testimony.

Mr. RIORDAN. Basically, I was simply going to state that EPA has been an active participant in the National Acid Precipitation Assessment Program. The inter-agency process involved in coordinating research has been fundamental in providing an effective forum, in our mind, for planning, for designing, implementing, and evaluating the research and monitoring activities that are relevant for policy in the acid deposition area.

Without that coordination, the research, in our view, would have been piecemeal. The results would have been fragmented, and probably not as useful to the policy making processes as the NAPAP results have been.

Some of the areas that EPA has done research in, and where we felt that inter-agency cooperation and coordination were indispensi-

ble in providing outputs were the area of the development of emission inventories for sulfur dioxide and oxides of nitrogen. We have worked closely with DOE in that particular area.

In the area of wet deposition and dry deposition monitoring, there has been a cooperation on the part of EPA, NOAA, the Park Service, and Department of Energy.

In the area of the national surface water survey, where the Forest Service actually did the sampling as part of our western survey, we had great cooperation from other agencies, as well—USGS, in particular.

In the area of effects of acid deposition in forests, we think that we have worked up a very close relationship, and a productive one, with the Forest Service as a result of the sponsorship of cooperation under NAPAP.

And finally, in the area of the effects of acid deposition on materials and crops, we also had inter-agency cooperation and coordination.

Most of EPA's research as part of NAPAP was designed with the 1990 program conclusion in mind and with the needs of policy. Most of our activities are designed to end in the 1989 and 1990 period. However, we will be continuing some additional research and monitoring activities beyond 1990 in support of implementation of the control programs of EPA.

In particular, we expect to maintain and improve inventories of emissions of man-made sources. We expect to maintain our regional acid deposition model, which predicts the effects of patterns of emissions on deposition in support of the implementation activities of the agency. And, finally, we intend to continue our support of wet and dry deposition in order to assess the impacts of control programs on air concentrations and deposition.

These activities, as I say, will be in direct support of the policy needs of the agency.

Finally, I'd like to say that the acid deposition research program that was conducted cooperatively across the Federal Government, in our view, has produced a substantial body of scientific information on all facets of the acid deposition program, and I think that anyone can readily conclude, once reviewing this, that NAPAP has been highly successful in achieving its fundamental goal: to provide advances in scientific knowledge in support of policy relative to this problem.

Thank you.

Senator BAUCUS. Thank you, Doctor Riordan.

What do the EPA and the Administration face on an acid rain bill based on the NAPAP study?

Mr. ROSENBERG. The research that was conducted by EPA and by NAPAP together helps clarify some of the scientific issues and really helps set the time tables.

The research was the basic scientific information to consider what the issues were and how to set the time tables. There were many more uncertainties in 1981, 1982, and 1983 as to the existence of the effect and the extent and magnitude of the effect than we now know about, I think. As Doctor Mahoney pointed out, results from the national surface water survey have indicated, for the first time, what the level of acidification is. We have attempted

to differentiate between what was historical and what was related to man-made factors and basically focus on what the result of emissions control might be on streams, on crops, and on lakes.

While we took that into account, we also went beyond the NAPAP study to focus on health and visibility studies that were being done by others to deal with the health and visibility questions, as well as ecological questions, and melding them all together. That was the basis for the present determination that the time for action was now.

I think it is very important to accept what Doctor Mahoney said in the context that this is not something if we take action in the Congress in 1989 or 1990 that is going to solve the problem in the short term. This is a fairly long-term effort. It will take ten years to get the controls on line. It will take many more years before the results are known. But we think—

Senator BAUCUS. I'm going to have to recess the hearing at this point. There is a vote in progress. We will temporarily recess for about 10 minutes.

Senator MOYNIHAN. We have three votes?

Senator BAUCUS. Three votes? We will be back as quickly as we possibly can.

Senator Moynihan will reconvene the hearing at the earliest opportunity.

Thank you.

[Recess.]

Senator MOYNIHAN [assuming the Chair]. I express our regrets that we have had to break in as we did. Now we can get on with other matters.

Doctor Riordan, we were hearing from you, and then had to break, so we will now resume, if that is possible.

Mr. Jordan, we want to welcome you here. You are chief of the Ambient Standards Branch of the Office of Air Quality at the EPA. It is very nice to have you at our hearing, sir.

Doctor Riordan.

Mr. RIORDAN. Senator, I think I have concluded my formal remarks, and I don't believe Mr. Jordan has any prepared testimony.

Senator MOYNIHAN. All right. Then let's just stay with the group a little bit.

First of all, I want to state what a very fine organization you have put together there, Doctor Mahoney. Somewhere in these papers is a list of the advisory council. Any advisory council that begins with Ken Arrow and ends with John Tukey is a pretty impressive advisory council. Oh, Doctor Russell is a member of that. I just happened to see that in glancing through. I don't know a more impressive body in my experience. I was once a member of the President's Science Advisory Committee—an honorary member. I was a member, but I'm not sure by the members I was a member, to paraphrase the joke from the Bronx. Still, I know more than half of the gentlemen involved here, and that is very impressive, indeed.

I want to go back now to the subject I was trying to get a little clearer and I will just use what is probably not correct, but the stickiness of these ratios, as I see them. I'd also like to try to get you to help me with some of these questions of probability.

The first thing is to say, again, that we have problems dealing with science on this committee, and with the scientific findings. They will typically assert levels of probability and confidence, and once you have raised the question of probability and confidence, you introduce lack of confidence in a way that normal language does not do. We have no graduate scientists on our staff. It is not an accident that we have no graduate scientists on our staff—we are afraid of them.

Science is intimidating, and if you don't have the faculties, then you could have come to us with data that says that if we do not end all coal combustion by the beginning of the next fiscal year, there will not be a tree living in the northeast by the year following, and presented that data, and we would not have been able to say you were wrong. We might have said we'd like a second opinion. We are, therefore, vulnerable to this kind of finding. And, mind you, so is much of the condition of modern government.

That's why President Eisenhower established a Science Advisory Committee—so he could hear something other than what the Pentagon was telling him. He had a good sense that maybe there was more than one view on matters—and, indeed, there usually are. But the views are classified, so we never do find out very much about that.

For example, you say here—and, again, it is when you move from the quantified statement to the verbal one—in your statement, Doctor Mahoney, you say that, "In my view, emission reductions in this range would benefit aquatic resources and would mitigate other environmental effects."

I happen to have been involved in a professional way with the analysis of the second largest social science research program in history, which was the study on equality of educational opportunity, which was ordered by the Civil Rights Act of 1964 and carried out by a team headed by James S. Coleman, then at Johns Hopkins, now at the University of Chicago.

He went through and found, in the course of this huge work, that aspects of school composition, pupil mix, something of that kind—they could discern differences in the outcomes of the levels of performance of students with these particular arrangements. The overwhelming finding was that the differences were minuscule—far from the expectation that there would be large and consequential. They were, in fact, minuscule. The systems were very slow, very unresponsive to change. First of all, they turned out to be much more alike than otherwise.

And then a series of court cases took place all over the country—not all over, but in many, many places in the country—in which expert witnesses would be called in and attorneys would say, "Does the Equal Employment Opportunity Survey show that there is a beneficial result as a consequence of having free encyclopedias?" There was no such question. As a matter of fact, encyclopedias in the home turned out to be one of the most powerful predictors of performance.

Let's say television in the classroom. Let us say they had, indeed, measured it, and that they had found an infinitesimal difference between classes that did and classes that didn't, they could measure it, and the classes that did were higher. You wouldn't walk

across the street for it, but they were higher. And, without question, witnesses said, "Was the performance of children in classrooms with, higher than classrooms without?" And the answer was, "Yes, Your Honor." Nobody had to be technically competent and say, "How much higher?" And large changes took place on the basis of a quite inadequate use of science data.

So here you are. I'm glad to see Senator Chafee present. We opened by saying, Senator, that 10 years ago on this committee we commissioned this work, and 10 years and half a billion dollars later we have the largest set of scientific research findings with respect to an environmental subject issue that we are going to try to legislate on in the history of this committee. Never before have we known as much and studied as long.

The question is, what have we learned?

I want to get two or three things straight at the level of what we both want to know.

You find a very high level of acidification in Florida, is that right?

Dr. MAHONEY. Yes, sir.

Senator MOYNIHAN. What are the levels of—what is the proportion of lakes that go beyond your ANC acceptable standards?

Dr. MAHONEY. Senator, I refer to page five in the prepared testimony, which has table one. You'll note for Florida the ANC—acid neutralizing capacity——

Senator MOYNIHAN. Did you say table five?

Dr. MAHONEY. I'm sorry. I misread it. It is page eight, Senator.

Senator MOYNIHAN. Table one?

Dr. MAHONEY. Table one.

Senator MOYNIHAN. Right.

Dr. MAHONEY. And I would refer to the fourth column over, which is acid neutralizing capacity less than zero. That is the most common working definition for acidic lakes.

Senator MOYNIHAN. Laymen should think that that lake can no longer exist—it no longer neutralizes deposition.

Dr. MAHONEY. It has no more buffering capacity.

Senator MOYNIHAN. No more buffering. Right.

Dr. MAHONEY. And you asked the percentage. This table is presented in percentages, and you'll note that 22 percent of the lakes in Florida——

Senator MOYNIHAN. It would help if it said percentages, incidentally, but go ahead. So 22 percent of the lakes in Florida have less than—you can't have less than zero, can you?

Dr. MAHONEY. Yes. Negative alkalinity. In other words positive acidity. Those are acidic lakes.

Senator MOYNIHAN. Okay. Well, it says zero or greater.

Dr. MAHONEY. Yes.

Senator MOYNIHAN. And so that has nothing to do with fuel combustion, or whatever, in your view?

Dr. MAHONEY. Well, sadly I wish it were that simple for all of this. It would not be right at all to say it has nothing to do with that.

Senator MOYNIHAN. Little?

Dr. MAHONEY. If I could make an overall estimate, my best estimate, looking at all the data, would be—we haven't run all that we

might for this case, in particular. My view is that less than half of this effect—and perhaps much less than half. It may be that only a small amount of the Florida lake acidity is related to deposition. But I could never say that deposition has no influence.

Senator MOYNIHAN. No is a word you probably rarely encounter. Zero is a term you rarely encounter. But the most acidified lakes in the country are in Florida?

Dr. MAHONEY. That's correct.

Senator MOYNIHAN. And this is not primarily to be associated, or even, perhaps, predominantly with deposition?

Dr. MAHONEY. That's correct.

Senator MOYNIHAN. It has to do with the geology of the area, the plants?

Dr. MAHONEY. Yes. And with the decaying organic material introducing organic acids to the lakes, and their particular characteristics of geology and watershed minerals, and their longstanding times in Florida.

Senator MOYNIHAN. Let's go back up to the top of table one, which is the next highest region in the Adirondacks, where 11 percent of the lakes—are these all lakes, or lakes of a particular—is there a cutoff in size?

Dr. MAHONEY. Yes. In fact, I want to expand the sense of coverage here as the text indicates. The lake survey for which these results are presented—the national survey had a size cutoff of four hectares. A hectare is 100 by 100 meters, or roughly two football fields. Or, to put it another way, that is almost exactly ten acres.

The choice of that cutoff was made years ago as a practical consideration in the development of this broad survey involving thousands of lakes.

In New York State, as you'll hear more in the second panel where you'll have a discussion of New York State and the Adirondack Lake Survey information, the smaller lakes—down to one half acre, I believe—were considered. The percentage of the very small lakes which are acidic is higher, and that's as we generally expect it to be.

Senator MOYNIHAN. But you had a four hectare cutoff?

Dr. MAHONEY. Four hectares, 10 acres, roughly.

Senator MOYNIHAN. Now, say as carefully as you can, again, what would happen to that figure of 11 percent if—well, just taking the hypothetical that the present pattern of deposition continued unchanged by statute or practice or whatever. What would happen to that?

Dr. MAHONEY. I think I can give our best estimate by specific reference to page 12, which has table 4. Here—now, this is for the entire northeast.

Senator MOYNIHAN. Northeast.

Dr. MAHONEY. Not simply the Adirondacks. But, you understand, the proportion would be roughly the same. In the northeast, reading from the left at the time from present—in other words, our present survey information indicates 162 lakes as being acidic; that is, having ANC less than zero. That's in the constant deposition column.

Now, if we read down that column so that we look at the time 20 years from now and then 50 years from now, we see that if deposi-

tion is unchanged, we don't expect to see any significant change. The projection is 162 changing to 161 20 years later at the present deposition levels. What that really means is no change at all. That's so small, given all the uncertainties, we would say that's the same thing.

Going out 50 years, the projection is 186 lakes in the northeast. Now, that also is such a small change that the proper scientific statement would be no significant difference.

Senator MOYNIHAN. The mathematics of 0.001, or something like that.

Dr. MAHONEY. Exactly. We might look at that and say we note the trend is increasing, so we're cautious. But the science would say it is not different.

Senator MOYNIHAN. John Tukey would say he doesn't see anything there.

Dr. MAHONEY. I agree. Yes, sir.

Senator MOYNIHAN. So if we do nothing, nothing is changed. And we live with the fact that 5 percent—about 1 large lake in 20—is going to be acidic, and that's where we are for the next 50 years.

Now, if we go to a decreased deposition, and that is taking the 10 million ton——

Dr. MAHONEY. This is approximately ten million tons, Senator. It is in the range. The point is that the decreased deposition column here reflects a 30 percent reduction from current deposition levels. And the 10 million tons of emission reduction would probably produce around 30 or 35 percent, but it would be in this range. So it is a good working number.

Senator MOYNIHAN. In 20 years, we would pick up 26 lakes?

Dr. MAHONEY. Yes, sir.

Senator MOYNIHAN. One lake a year. And we'd go from 5 percent to 4 percent.

Dr. MAHONEY. That's correct.

Senator MOYNIHAN. But then over 50 years you'd pick up 80 lakes, or 75.

Dr. MAHONEY. Yes.

Senator MOYNIHAN. Okay. I understand that. It would help if tables like this—there is no column head on the number in parenthesis that I gather indicate your levels of confidence. Would you explain that to me? I'm not used to level of confidences at 245. What does that mean.

Dr. MAHONEY. Well, the level of confidence in that case is best defined this way: it would be more clear if there were a plus or a minus 245. In other words, the meaning of this from the model calculations is that it is 95 percent likely that the actual numbers of lakes still acidic in 20 years will be 161 plus or minus 245. Now, since we can't have negative lakes acidic, what this very broad uncertainty band represents is that it is extremely difficult to project the chemistry of these watersheds. The number actually acidic over that time could be smaller than 161. Quite likely, it could be smaller by some amount. It could even be higher, though. Those are the limits of the ability to project in these cases.

Senator MOYNIHAN. Why don't you, as a practice—you do say plus or minus down here, but you—okay, it does say the 95 percent confidence level. We've got it.

And so we have to do—let's go back—I'm finishing my remarks, and then we'll go to Senator Chafee.

So when you say over on page two that an emission reduction would benefit and mitigate, let's put a number on benefit. How much would you—we talk about benefits and cost. For what cost do we get what benefit? And what are the alternatives?

Dr. MAHONEY. Well, I'll do the best I can to answer that. I don't want to be an "on the two hands" scientist, Senator, but it is important to be careful because it represents the limits of our knowledge.

The reason that statement is at the front of this whole testimony is that I want to acknowledge very clearly that we do expect benefits from emission reductions. And so that statement is placed here at the beginning to make it clear, before we enter into all this detail, that the detail should not be used to convey the impression that we don't expect any benefit to come from all these reductions.

Senator MOYNIHAN. Is that because your findings suggest not much benefit?

Dr. MAHONEY. I think that the interim findings did suggest benefits in a number of cases. That is the way I'd read it. But I am aware of that perception. Yes, Senator, I'd say, among other reasons, the reason for saying this clearly at the front is to make it clear that this detailed exposition of projections and uncertainty is not meant to cloud or take away the view that there are benefits of many sorts that will come.

Senator MOYNIHAN. Well, what are the costs?

Dr. MAHONEY. I will indicate the number which EPA has prepared and used with the Administration bills. We are doing control cost estimates, but we don't have them available at this time, so I can't make our own up.

Senator MOYNIHAN. Mr. Rosenberg.

Mr. ROSENBERG. We estimate about $4 billion a year, Senator.

Senator MOYNIHAN. Four billion dollars a year?

Mr. ROSENBERG. Right.

Senator MOYNIHAN. Okay. So we have to ask ourselves whether that is the best way to spend $4 billion a year? Let's see. In New York State we have one million abandoned women and children—some are people on welfare. That $4 billion would come to $4,000 times one million, right? So if we gave every family—the typical family is a little under three, but say $3,000. We could, with that money, give—obviously, this is very hypothetical— give every welfare family $12,000 to vacation in the Adirondacks on some of the 95 percent of the lakes that are not acidic.

Does it hurt you to swim in acidic water?

Dr. MAHONEY. No, sir. Not in this range. If it is acidic enough, yes, sir. But not in the range we are speaking about.

Senator MOYNIHAN. As a matter of fact, one of the strange things is, that these lakes are more beautifully blue because there is no aquatic life. They look like your ideal lake, actually. They obviously are not.

So we could give every welfare family in New York State a three month summer vacation in the Adirondacks with the same amount of money. I'm just saying there are trade-offs. That's all I'm saying.

Mr. ROSENBERG. Senator, I think it is important to note that there are other benefits besides the lake benefits.

Senator MOYNIHAN. Of course.

Mr. ROSENBERG. In relating to health and——

Senator MOYNIHAN. I introduced this bill, before anybody knew there was acid rain.

We thank you very much.

Senator Chafee.

Senator CHAFEE. We've got another panel, and if I have any question I can locate these folks here, so why don't we get on with the other panel.

I tell you one thing, they're not going to go away and burn any flags in a national forest.

Senator MOYNIHAN. We do thank you very much.

We thank our associate over there who handled those tables so nicely. I wish our eyesight was better.

We have a very special panel. First we have Doctor Milton Russell, who is at the University of Tennessee and the Oak Ridge Laboratory. With him we have Mr. Walter Kretser, who is the Project Director for the New York State Adirondack Survey Corporation. And George Hidy, who is the Vice President for Environmental Affairs of the Electric Power Research Institute in Palo Alto.

Doctor Russell, you were once an assistant administrator at EPA, were you not?

Mr. RUSSELL. Yes, Senator.

Senator MOYNIHAN. I think we have heard from you before in this committee, and we welcome you back.

Could I point out to Mr. Chafee that Doctor Russell is the chairman of the advisory board oversight review board that was set up by NAPAP. It is as distinguished a group of scientists as I have ever seen on one of these boards. I'm interested that Doctor Bailar, who is on the faculty of epidemiology and biostatistics at McGill, is present.

Doctor Russell, we welcome you, sir.

**STATEMENT OF MILTON RUSSELL, CHAIRMAN, NAPAP OVERSIGHT REVIEW BOARD, UNIVERSITY OF TENNESSEE/OAK RIDGE NATIONAL LABORATORY**

Mr. RUSSELL. Thank you, Senator.

I do have a written statement, but I will just leave that for the record.

Senator MOYNIHAN. All statements will be inserted in the record.

Mr. RUSSELL. I am pleased to accept your invitation. As you note, I appear here as chairman of the Oversight Review Board for NAPAP.

The Board was established by the Joint Chairs of NAPAP, and its responsibility, if I may quote, is to "provide advice to NAPAP management and the Joint Chairs Council regarding the quality, scientific integrity, credibility, and practicality of the many different parts of the NAPAP final assessment." It is not part of the Board's mandate to undertake a review of the science that exists beneath each of these findings. But it will examine the peer review processes that are to be followed.

Senator MOYNIHAN. Could I ask you to say that once again?

Mr. RUSSELL. What I said was that it wasn't part of the board's mandate to undertake a review of the specific science underneath each of these findings. What we will be doing is examining the peer review processes that are going to be followed and to seek to assure that canons of scientific impartiality are faithfully applied.

We are going to be encouraging scientific and technological consensus whenever it is possible, and will try to assure a fair hearing for other opinions when a consensus can't be reached.

With you, we believe that the Joint Chairs and the director of NAPAP deserve high commendation for empowering a board of this sort to oversee the culmination of the ten-year effort.

It is not within my role, for these reasons, to talk about the substance of the hearings today, but I do think it proper to comment on the second part of your request, which is: "What happens after the mandates of NAPAP expire?"

This issue, though, hasn't been taken up formally by the Board, and so my comments on it don't represent a considered position taken by it.

I note, as you have this morning, that the NAPAP research program is entering its tenth year. It is certainly understandable that the reaction would be, "Surely we now know enough." But, as we have also discussed this morning, acid precipitation research is the process of unfolding answers. It is a gradual refinement of hypotheses, and some of these may prove to be wrong. So there is no reason to believe that all the truth is going to be out by the end of 1990. You know well that science doesn't work that way.

Now, that doesn't mean that I'm suggesting that decisions should be delayed for interminable rounds of additional research. What I am suggesting is that there will be a continuing need for further work to refine what we think we know, to test these hypotheses against a natural world that doesn't respond to a policy-driven calendar and to monitor the changes that we see in emissions, in depositions, and effects.

There is another matter that is perhaps more important. Unless some provision is made, it seems to me, once NAPAP disappears and the inter-agency work groups disband, institutional cohesion and the institutional memory are going to dissipate. For example, data bases are going to become solely the responsibility of the agency that developed them, and they are going to be maintained if, and only if, those data bases are consistent with its mission. Some will be allowed to live and will be available; but others will be allowed to wither and become dysfunctional and ultimately die.

That means that evidence for possible mid-course correction may not be available when it is needed. And, more immediately, policy implementation of whatever decisions are made is going to require access to this information and, if it is scattered among agencies, it is going to be difficult to assemble and to be used effectively. For that reason I believe that the Committee is farsighted and wise, even at this early stage, to invite consideration of what happens after 1990.

My own opinion is that the Nation will get full return for its very large investment only if some thought is given soon to the in-

stitutional arrangements that are going to be in place to exploit that investment as far as the future is concerned.

So, Mr. Chairman, to close my statement, we welcome the opportunity to explain the Board's role to the committee. And, as is consistent with the Board's mandate, we will be pleased to cooperate with the Congress in any way that you request. But our goal is to assure, to the extent we can, that the scientific information available to the public is as complete and as reliable and as usable as possible.

If you have any questions, I'll be happy to answer them.

Senator MOYNIHAN. Thank you very much. I think we'll probably wait until we hear all of the testimony of your associates before we ask any questions. But we do very much thank you for that.

Mr. Kretser is next on our list.

## STATEMENT OF WALTER KRETSER, PROJECT DIRECTOR, NEW YORK STATE ADIRONDACK LAKES SURVEY CORPORATION

Mr. KRETSER. Thank you, Senator.

Senator Moynihan and Mr. Chafee, my name is Walter Kretser, and I am employed by the New York State Department of Environmental Conservation in the Division of Fish and Wildlife, Bureau of Fisheries, as a research scientist.

Since 1980, I have been involved in acidification studies. And since 1983 I have been assigned as the project manager for the Adirondack Lakes Survey Corporation.

The Adirondack Lakes Survey Corporation was formed by the New York State DEC and the Empire State Electric Energy Research Corporation to conduct extensive biological, chemical, and physical surveys of Adirondack waters to provide a basis for better understanding of the acidification problem in this vast, wild region in northern New York.

This $5.3 million project involved four years of intensive field and laboratory work that resulted in the most comprehensive data set ever assembled in the United States on aquatic systems. A total of 1,469 individual waters were invested from 1984 to 1987 out of a known population of 2,759 waters. Lakes and ponds surveys ranged in size from small, one-half acre ponds to waters as large as 700 acres.

In 1984, the EPA eastern lakes survey also collected information on a subset of 149 Adirondack ecological zone waters. But in that survey, as you heard Doctor Mahoney say, waters less than ten acres or four hectares in size were not included as part of the population when, in fact, they make up at least 47 percent of the waters located in this region of the State. Although we understand the rationale used in this decision, we do not concur with the results.

The goal of the Adirondack Lakes Survey Corporation was to complete comprehensive fish and chemical surveys of lakes and ponds within the Adirondack ecological zone to provide an accurate, up to date, comprehensive data base for making current fisheries management decisions and providing a basis for assessing environmental impacts and associated trends.

The objectives were to determine the status of fish populations and water chemistry.

Five field teams focused sampling efforts on the five major watersheds of the Adirondack ecological zone. These represented approximately 6.5 million acres.

From 1984 through 1987, ALSC biologists completed surveys including spring or fall fisheries and chemical investigation, intensive midsummer chemical sampling and bathymetric mapping on 1,469 waters, or 53 percent of the total number of waters in the region of study.

Survey waters were selected utilizing a modified random selection process. Surveyed waters ranged in elevation.

Water samples were collected from each water at least two times. More than 4,200 water samples were analyzed for 24 different parameters.

The results of these analyses indicated that air equilibrated pH values for surface waters ranged from 3.9 to 8.9. An additional 269 waters had pH values from 5.1 to 6.0, falling into the "endangered" category under this same classification.

Fish populations were present in 1,123, or 76 percent, of the waters surveyed.

All data collected from 1984 through 1987 was compiled into 18 separate volumes, each containing individual pond data consisting of 16 record types. We are currently working with NAPAP staff to make certain that the results of this research are included in the state-of-science draft scheduled for public review in November.

In my opinion, acidification is a serious problem in the Adirondack region of New York. Because the southwestern area of the Adirondacks is located downwind from identified sources of pollution and receives the highest sulfate and nitrate loading in the state, it is essential to determine the relative importance of acidity sources. An attempt to identify the relative importance and contributions from these sources is currently underway by the ALSC interpretive team.

It is also my opinion that a commitment to long-term monitoring programs that include a strong biological component is essential; otherwise, trend data will not exist.

The episodic response program that we are currently involved in with EPA appears extremely important in that biological and chemical responses to atmospheric events can be observed and documented quickly. This program should be linked to or become part of a long-term monitoring program.

We believe the information obtained by the four-year Adirondack Lake Survey study will broaden this foundation considerably.

Thank you.

Senator MOYNIHAN. Thank you very much, sir.

Now, Doctor Hidy. We welcome you all the way from the other coast.

## STATEMENT OF GEORGE HIDY, VICE PRESIDENT, ENVIRONMENT DIVISION, ELECTRIC POWER RESEARCH INSTITUTE

Dr. HIDY. Thank you, sir. And thank you for the invitation to join you today.

Today, I will give you a different perspective about the scientific issues relative to EPA's position. I will give you an expression of

EPRI's opinion as a research management institution that has invested a great deal of time, effort and money on the behalf of the electric utilities on the subject of acid rain, its origin and effects.

Let me summarize, the points I'd like to make for this hearing. These points are also in my written testimony, and are discussed there in detail.

First, research during the past decade on acid deposition has provided critical information for decision makers like yourself either in new definition and discovery, or in refinement of earlier knowledge. Much of this information comes from the National Acid Precipitation Assessment Program (NAPAP) and its cooperative activities with other organizations.

The second point is that research confirms certain effects associated with manmade sulfur and nitrogen oxide emissions. At atmospheric levels, these effects focus on changes in surface water chemistry, deterioration of materials, and visibility impairment.

The third point is that none of the identified effects are geographically widespread or represent rapid environmental deterioration. Therefore, there is time for a considered, well-planned strategy to reduce $SO_x$ and $NO_x$ emissions if deemed desirable to secure against possible adverse environmental change in the long term.

In conjunction with that timing, it is very important to take maximum advantage of new technology which is currently undergoing demonstration or will undergo demonstration in the near future.

A selective control strategy to reduce exposure at sensitive receptors while minimizing cost is important, we believe, for decision making. Source receptor modeling can be used to facilitate this requirement and to our knowledge, has not been done in developing proposed legislation.

The fourth point is that research indicates that the currently proposed strategy for reduction in sulfur and nitrogen oxide emissions may not result in meaningful environmental improvement of lakes and forests or material damage reduction over the next half century.

As the fifth point, environmental benefits are perceived to be very limited compared with the estimated high cost of proposed emission control. An environmental benefit versus emission reduction cost analysis, in our opinion, is essential to support the proposal for a ten million ton per year $SO_x$ reduction.

The sixth point: if low alkalinity lakes—which have been primarily the subject of this hearing, so far—are the focus of concern, we believe that liming treatment offers one important, cost effective, environmentally benign alternative that will predictably improve the lakes' acidity status. This is in contrast to emission controls that are proposed.

The seventh point is that the future for research should not end with NAPAP. That is, the expiration of NAPAP in 1990 should not inhibit planning and execution of continuing research on acid deposition or related issues.

Senator MOYNIHAN. Can I just ask you if you are suggesting that NAPAP should wrap up? Or are you suggesting it should be continued?

Dr. HIDY. What form organized research takes, Senator, is really the decision of the Congress and the agencies and the Administration. But I believe that the research, achieved so far will have unfinished business. A continuing research agenda will insure greatly improved knowledge about the long term impact of acid disposition.

As for EPRI's work, we plan to continue research in environmental $SO_x$ and $NO_x$ behavior, including health effects, the issue of forest response, and the mathematical determination of the source/receptor relationships.

We also feel, that NAPAP has been a successful organizational experience and experiment in a national sense, and that whatever research is done either formally or informally should include some form of inter-agency communication and cooperation.

I also would like to reinforce Dr. Russell's point that predictive models need to be unified, and hypotheses need to be tested with a long-term set of observations.

Part of the extended research program should involve long-term environmental monitoring. Monitoring would be desirable to track the chemical deposition, surface water chemistry, soil, and forest ecosystem characteristics. There data will be important to verify our understanding of our predictions compared with the real world.

And finally, Senator, I would like to comment on the NAPAP experience. As I mentioned before, I think it has had a very positive benefit to the public. NAPA has produced a great deal of new information that is available to you in the Congress. I hope you take advantage of it in your decision making. The value is not only in decision making, but also in education of the public. Perhaps most of all, NAPAP has promoted the cooperation of a very large number of scientists who come from many different disciplines to work on an extremely complex area of man's influence on natural processes.

So we recommend this kind of cooperative in the future, and we have hopes to contribute and participate in similar ventures.

Thank you.

Senator MOYNIHAN. I do thank you all.

Senator Chafee hasn't had an opportunity to ask questions yet, so why don't we begin with him?

Senator CHAFEE. Thank you, Mr. Chairman.

As I understand the testimony here, people are prepared to say that damage has been done to lakes—and certainly Mr. Hidy would, as I understand his position—but that we are not sure of the most cost effective way of remedying any damage that does exist, and that it may well be that liming the lakes is a more cost effective way before there is further research to determine exactly an alternative way if, indeed, there is. Is that a fair statement?

Dr. HIDY. Yes, sir. If you focus on the lakes as the desired environmental protection objective, liming is much more cost effective than emission control in our calculation. However, it does focus on a single issue of the lakes and does not take into account a variety of other possible mitigation necessary.

Senator CHAFEE. Such as the soil?

Dr. HIDY. Well, it can take care of the soil, too, by liming in the watershed areas. Certainly it would be impractical to lime the

entire Adirondacks, basically. But as far as the watershed is concerned, this is one method of getting the lime into the lakes.

Senator CHAFEE. Now, Mr. Kretser, I understood from you that, although you have done a lot of research, we ought to do some more.

Mr. KRETSER. Well, we've done a lot to date, certainly. I think we have enough information on lakes and ponds to know what the damage is out there. Our sampling efforts basically was a census of what is there. We did over 53 percent of the ponds and lakes in the area.

My feeling is that we have very little information on the thousands of miles of headwater streams. Based on the effort we are involved in right now, we are seeing significant changes in both chemistry and biology in these very small headwater streams following a storm.

Senator CHAFEE. And where do you think that is coming from?

Mr. KRETSER. Well, it is coming from whatever inputs are coming from the atmosphere.

Senator MOYNIHAN. Excuse me, Senator, for one comment?

Senator CHAFEE. Sure.

Senator MOYNIHAN. This is one of those ironic things, if you know the Adirondacks. We have a treasure for New Yorkers that is twice the size of Yellowstone. It is kind of disillusioning when at about age 30 you find out it is not virgin forest. It was stripped bare. There wasn't a twig left when Theodore Roosevelt bought it for 10 cents an acre.

But we have since measured everything from the first robin has been recorded—the first robin to appear—to the last leaf to drop from the yellow aspen. But the one thing they never recorded was the pH content of the lake.

So if I asked you if there are more acidic lakes in the Adirondack today than there were in 1900, you would have to answer——

Mr. KRETSER. We don't know the answer to that.

Senator MOYNIHAN. That's all right. You know what you know. Don't be afraid of trying to live with the numbers. I just thought that was kind of curious.

Senator CHAFEE. That is interesting. Frankly, I didn't know it was Theodore Roosevelt, as Governor, that purchased that land, which is written into the Constitution, as I understand, for protection.

Senator MOYNIHAN. It is forever wild. You get the impression it was forever wild, but not so.

Senator CHAFEE. Also, there are a lot of private enclaves within the forest.

Senator MOYNIHAN. Yes.

Senator CHAFEE. What percentage of the total? Never mind. We had better get back to work here.

Mr. Kretser, where does this end? Here we are. What is your suggestion to this committee? Wait some more? Don't do anything?

Mr. KRETSER. No. I'm not suggesting that at all, Mr. Chafee. What I'm saying is that what we should gear ourselves to now is a long-term monitoring program. If controls go into place—and we assume that there will be controls—then we need to be able to

measure the relative effectiveness of these controls. Are we, in fact, seeing positive or no change in our water bodies?

Senator CHAFEE. But if it is going to cost us $4 billion a year to have these controls, as Mr. Rosenberg indicated, what is your recommendation to us about proceeding with the controls reducing emissions by ten million tons of sulfur dioxide a year?

Mr. KRETSER. Again, I have no idea what the effect will be with controls. A certain percentage of our lakes we expect would respond. We don't even know what that percentage is. We hope to know within the next month, based upon the interpretation of the Adirondack Lakes Survey data.

Senator CHAFEE. Well, let me put it this way: do you think that sulfur emissions have caused damage to the lakes that you studied?

Mr. KRETSER. A certain proportion, yes. But I cannot name that proportion.

Senator CHAFEE. What else caused the damage, if there is damage there? Maybe there is no damage.

Mr. KRETSER. There is certainly damage there, as we have 325 acidified waters out of 1,469 that we looked at.

Senator CHAFEE. What do you think caused that?

Mr. KRETSER. We had 346 without any fish.

Senator CHAFEE. Okay. Now, what do you think caused that?

Mr. KRETSER. Well, the numbers of waters without fish can occur from a number of reasons, including atmospheric deposition or changes in chemistry. It can also occur from changes in fish management strategy, perhaps. Certainly if you stop stocking a water that relies entirely on stocking to survive you lose your fish populations. The loss of spawning habitat in waters will reduce fish populations. Just winter kill—heavy snow, no oxygen. There are a number of reasons—water becoming a bog in its succession trend. Bog water——

Senator MOYNIHAN. Eutrification?

Mr. KRETSER. Eutrification. So there are lots of reasons, but there is also a component of waters out there that we feel have lost populations as a result of change in chemistry, and we're trying to identify that source of change, obviously.

Senator CHAFEE. I don't want to be harsh, but here we have had this 10-year study. We have been at this—as the majority leader said, he doesn't want to make a career out of this business of working on acid deposition and clean air. After all this, you, who spent a lot of time on this, would—what is your recommendation to us?

Mr. KRETSER. Again, all I can say is from my own opinion and from the involvement that I have had on a very, very intensive study. There certainly are lots of waters out there without fish and lots of them that are acidified. The effort that we're making now to identify why they are acidified—I think that will give you a basis for making a decision. If the research scientist team that we have—which are the best in the country—come up and say 90 percent of the waters that you no longer have fish populations in—and this is hypothetical—are the result of atmospheric deposition, then something should be done.

If they say, on the other hand, 2 percent, then I guess you'd have to weigh that.

Senator CHAFEE. And when are your people going to have this?

Mr. KRETSER. This report is scheduled to be due at the end of this month. We have a meeting on October 19 and 20 to review the segments of this interpretation document.

Senator MOYNIHAN. Senator Chafee, would you let me say something here in the spirit that we have worked in this committee a long time? I said this at the opening, but maybe you didn't hear me. You can observe the fact that—I don't know if you can quantify it, but you can observe—people involved with the environmental movement, as you are, and I think I am, get very nervous when they hear the subject of research because, among other things, they will always learn at the end of a period of research that more research is needed. And if there is anybody present who has done research and has witnessed any other conclusions, please rise now or forever hold your peace.

That is the process by which we learn about things. And if you take from that the thought that this research is indeterminate and is an excuse for inaction is almost a sin against the Holy Government. I mean, it defies five centuries of western experience of what does happen with inquiry.

I would make the point that the people who fear research might find out things that you don't want or they might be inconclusive.

Can I point out that is only when you are in the first phase of this kind of work when most of the people involved are true believers and there is very little—you rarely encounter someone saying "prove it."

But we went through eight years of the previous administration on acid rain, and every time anybody went into the White House or the OMB, in particular, and said they think we should do something, they were met with a fairly sophisticated inquiry of why.

Well, because.

Because why? It's hurting people? Who?

Killing lakes.

Which?

We need to clean them up.

At what cost?

Invariably, those questions had no response. There was no answer. So in other words, you don't know what you're talking about. Thanks very much. Next case.

And now we begin to know. And it is not as reassuring. It is not as dramatic. In many ways, it is very reassuring. It suggests to me that the sky is not falling. I'm glad to hear that. But when they say, for example—Doctor Russell, the NAPAP studies won't really be finished until about January, isn't that right? You're going to have a big, international conference?

Mr. RUSSELL. That is be scheduled for February.

Senator MOYNIHAN. February. Okay. Well, you can reach out and touch February. But at that point you are going to have people from all over the world, aren't you?

Mr. RUSSELL. Correct.

Senator MOYNIHAN. The next time an OMB director says prove it, well say, "Here."

Mr. RUSSELL. I'm not sure it is going to be that clear.

Senator MOYNIHAN. But will you accept my thought it can be made very clear that you don't have any facts.

Mr. RUSSELL. That's a possibility.

Senator MOYNIHAN. In a situation where you don't, it doesn't take much sophistication to establish the fact that you don't. Prove it.

That is exactly what I said. When the man who says prove it has the advantage over the man who has to do so.

Mr. RUSSELL. And over the man who has to take action or not take action——

Senator MOYNIHAN. The man who has information can say, "Here is the proof. Now you disprove it."

Senator CHAPFEE. Doctor Russell, let me change the subject. I was interested in your very distinguished committee. The fact that it was so recently appointed—and I know that in your statement you made clear what you are not meant to do. But it seems to me that to come aboard, as you are in your particular overseeing function, if you want to use that word, at such a late state and stage in the game—this study has been going since 1980, and you were informed—I guess the invitations went out this summer?

Mr. RUSSELL. That's correct.

Senator MOYNIHAN. You had your first meeting in September?

Mr. RUSSELL. That's correct.

Senator CHAFEE. And the study is going to wind up at the end of this year. Is it the end of this year? It is in 1990 that it finishes. When in 1990? A year from now. So do you think that your group can do much good—I guess I have to put it that bluntly—since you have not been tracing the research as it went on? You are now reviewing the how they are going to disseminate it and seeing that the endeavor is truly scientific, as I understand your charge. Am I correct?

Mr. RUSSELL. That's correct. Let me respond, Senator, not from the standpoint of the Joint Chairs and the Director of NAPAP, who determined the timing of establishing the committee, but from what we seek to accomplish, ourselves.

You are quite correct that we are not there to oversee whether or not the number should be 10 percent of the lakes or 11 percent of the lakes. We don't have the expertise and the breadth of expertise on the committee, and that's simply not our mandate.

What we can do is to assure to the extent possible that the research gets put together in a scientifically responsible sort of a way. What that means is to assure that the peer review processes which are subject to the canons of science indeed are followed. And that the presentations of the lay summaries and of the final assessment report—which are extremely important in terms of what the people are going to get out of this; what the truth, as it is now, will be—are put together in a responsible way.

We can be available to deal with problems of lack of consensus on the part of the scientists—and, undoubtedly, there will be lack of consensus and there will perhaps be controversies of that sort. We can provide a group of persons who seek to bring about some of that reconciliation on a scientific basis rather than on some administrative or other kind of basis.

So I don't suggest that this committee is going to be able to solve all of the problems or assure in each and every way that everyone becomes satisfied with NAPAP. But it does provide a scientific

process for resolving some disagreements, and it does provide a body to oversee the process from the point where we are now to where we would be.

To give one further example, had we or others been empaneled at an earlier time, perhaps different types of research would have been suggested that should have been done. That point is beyond us now. We are dealing with what is, and trying to bring it to as successful a completion as possible.

Senator CHAFEE. I think Bill Reilly was wise to form this group. I was just curious why it went beyond the standard procedure with such a mammoth undertaking—$500 million. Even for somebody from Washington, that's a lot of money. It didn't seem to me quite normal to have an oversight board come at such a late point.

Mr. RUSSELL. Could I comment on that, Senator?

Senator CHAFEE. Sure.

Mr. RUSSELL. In fact, I believe that they deserve special commendation because such a process is not normal. It is not usual for an inter-agency process—for a group of persons in an Administration—to voluntarily undertake to subject their activities to review by an outside review board of independent scientists. And I think it is to their credit that they sought the review ahead of time, in real time, when it perhaps can make some difference, rather than, as is most often the case, after the fact. When the findings are already in the public mind and attitudes are formed and "Who did what to whom?" is of only historical interest.

So you may suggest it is late. I am suggesting that it is a gratifying example of what I think is a good government practice that it happened at all.

Senator CHAFEE. Thank you.

Thank you, Mr. Chairman.

Senator MOYNIHAN. I just don't understand this. As I say, science frightens people. John Tukey and Milton Russell are not window dressing. As a review board, you really wouldn't have much to review until the later stages of a work; isn't that right?

Mr. RUSSELL. That would be my opinion, Senator.

Senator MOYNIHAN. And towards the end you'd look at it. I want to thank you all. I want to say that I hope it is understood that what we're trying to do here, in the beginning, is to establish a defensible basis for action—whatever that may be. I do very much think that we want to continue this monitoring. The idea of some international effort I think is important.

Would you agree with my thoughts earlier on that we probably now know more about this subject than anybody? The Europeans haven't gotten—you would have thought by now——

Senator CHAFEE. I wouldn't dismiss the Europeans casually.

Senator MOYNIHAN. I'm not stating; I'm asking.

Mr. RUSSELL. I would only observe, Senator, that the Europeans and the Canadians, in some sense, have been part of the process because the research results that they have generated have been brought into the system.

Senator MOYNIHAN. But evidently the Europeans are very much impressed with what we now have, and they don't seem to have quite as comparable a body of data; is that right?

Mr. RUSSELL. I couldn't comment on that, sir.

Senator MOYNIHAN. I just have the impression that they don't. The big question——

Senator CHAFEE. Let me just chime in there. I had the privilege of going to Stockholm and seeing what they're doing, and the Swedes, overall, were very, very impressive. Now, I'm sure it is not on as big a scale as we do, but don't brush aside what they are doing. They're deeply into the liming business. I saw the whole process, and——

Senator MOYNIHAN. This committee is going to Stockholm. Good idea.

Senator CHAFEE. I think we should.

Senator MOYNIHAN. We're going to have a great representation of Europeans in that meeting in February, right?

Mr. RUSSELL. Yes, sir.

Senator MOYNIHAN. And I see there is a Canadian on the board, but we obviously want to consult with them and see if it fits with their understanding.

Gentlemen, thank you very much, and congratulations.

[Whereupon, at 12:51 p.m., the subcommittee was adjourned, to reconvene at the call of the Chair.]

[Statements submitted for the record follow:]

TESTIMONY OF
JAMES R. MAHONEY
DIRECTOR
NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM

BEFORE THE
SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE

OCTOBER 5, 1989

Mr. Chairman and Members of the Subcommittee, I appreciate your invitation to appear before the Subcommittee today, to present testimony on the scientific and technological aspects of acidic deposition and its control. The National Acid Precipitation Assessment Program was created by Congress in 1980 (Public Law 96-294) to conduct scientific, technological, and economic analyses of acidic deposition causes and effects, and to evaluate the available approaches to its control. The statute assigns NAPAP the responsibility of reporting its assessment findings for use by the President, the Congress, and the public. To meet this responsibility NAPAP has (1) conducted its own research through its participating Federal Agencies and Departments, (2) analyzed other relevant technical studies conducted in the United States and in other nations, and (3) established an assessment framework to report complicated technical information in a manner useful to policy officials and the interested public.

My testimony today summarizes much of the current scientific information about acidic deposition effects, and describes key findings from some recently completed projections of future surface water chemistry at different deposition levels. NAPAP is preparing a broad set of projections to compare the range of control costs and environmental benefits associated with various levels, schedules and geographic patterns of emission controls. While many of these projections are not yet available, I want to give you the sense of my

current scientific judgment. As a reference point for my comments, I note that you are considering several suggestions for $SO_2$ emission reductions of ten million short tons below 1980 levels. In my view, emission reductions in this range would benefit aquatic resources and would mitigate other environmental effects caused by acidic deposition and its precursors as described in this testimony and other NAPAP reports. To preserve its credibility as technical fact finder, NAPAP does not make recommendations about specific control levels. We recognize that you in the Congress, together with the President and his policy officials, must make these decisions after considering the available scientific information and weighing many other concerns.

NAPAP has established guidelines to report two types of information in its assessment:

(1) The best technical conclusions supportable by evidence. NAPAP's comprehensive assessment reports are being subjected to intensive scientific peer review, interagency review, and open review by all interested members of the scientific community and the public, to assure soundness and objectivity in the reported findings.

(2) Descriptions of the confidence level associated with each conclusion. Given the complex task of isolating the environmental effects of acidic deposition from other sources of variability, such as natural stresses and various anthropogenic factors, a degree of scientific uncertainty is unavoidable. NAPAP's technical findings are being coupled with explicit statements of confidence levels to aid decision-makers in using the information.

NAPAP's assessment reports, scheduled for completion at various dates between December 1989 and September 1990, are currently in preparation and review. NAPAP will provide each of these reports to the Congress as soon as it is available.

The remainder of my testimony is divided into three parts. First, NAPAP's current information on acidic deposition effects and the status of control technologies is summarized, as background for your consideration of proposed legislation. The second part notes some of NAPAP's key accomplishments, to document how the research and assessment program has greatly improved our understanding of acidic deposition. The final part responds to your question about the potential use of continued data collection after NAPAP's mandate expires in 1990.

PART 1 - SUMMARY OF SCIENTIFIC INFORMATION

Sources of Acidic Deposition

The chemical precursors involved in producing acidic deposition are sulfur dioxide, nitrogen oxides, and volatile organic compounds. Sulfur dioxide and nitrogen oxides are produced in the combustion of fossil fuels. Volatile organic compounds are emitted from many industrial, transportation, and natural sources; these compounds, acting together with the nitrogen oxides, produce oxidants involved in the conversion of sulfur and nitrogen oxides into acidic compounds.

NAPAP has developed a comprehensive inventory of anthropogenic emissions for the United States and Canada for the base years 1980 and 1985. Estimated anthropogenic emissions for the United States for 1985 are:

- 23 million short tons of sulfur dioxide (70% from electric utilities),
- 21 million short tons of nitrogen oxides (40% from transportation sources, 33% from electric utilities), and
- 22 million short tons of volatile organic compounds (40% from transportation sources, much of the rest from solvent evaporation).

NAPAP has also estimated annual emissions trends through 1987, with preliminary estimates for sulfur dioxide and nitrogen oxides for 1988. Between 1973, the peak year of sulfur dioxide emissions, and 1988, sulfur dioxide emissions in the United States decreased by 23% from approximately 31 to 24 million short tons, despite a 45% increase in coal use. The decrease resulted from increased use of low sulfur coal and flue gas desulfurization (scrubbers), increased nuclear power production and decreased utilization of some higher emitting power plants and industrial sources. Most of the reduction was achieved by 1982; during the last six years sulfur dioxide emissions have remained relatively constant.

Emissions of nitrogen oxides peaked in 1978 at 23 million short tons and have since declined. Preliminary estimates of 1988 emissions are 20 million short tons, which is a 14% decrease from 1978. Emissions of volatile organic compounds have also decreased during the last ten years; preliminary estimates for 1988 are 21 million short tons, which is a 28% decrease since 1978.

Natural sources of sulfur emissions in the United States are minor by comparison to anthropogenic sources. Natural sources of nitrogen oxides are also estimated to be small, but in some areas important, in the United States compared to anthropogenic sources. Although less certain, regional estimates of volatile organic compounds emissions from natural sources are approximately as large as anthropogenic sources.

Future levels of anthropogenic emissions will be determined by many factors in addition to implementation of emission controls. Among the most important for sulfur dioxide are regional patterns of population growth, future energy demand and the rate of retirement or repowering of older, higher emitting power plants.

## Effects of Acidic Deposition

The six principal categories of acidic deposition effects to be included in NAPAP's final Assessment are: aquatic ecosystems, forests, crops, exposed

materials, human health, and visibility in the atmosphere. My statement today covers the first four of these categories, for which NAPAP has sponsored extensive research. Because acidic deposition emission precursors may also affect health and visibility, NAPAP also monitors and evaluates research activities in these areas and will report on these areas in its Integrated Assessment. Each of the effects categories addressed considers two key questions: (1) what damage can be attributed to current levels of acidic deposition?; and (2) what benefits (i.e., reduction in physical and/or economic damages) would be expected to result from reduced levels of acidic deposition?

Effects on Aquatic Ecosystems

The potential acidification of aquatic systems resulting from acidic deposition has been a driving influence in research and control activities in Europe (especially the Scandinavian countries), in Canada and the United States, and more recently in other nations. It is widely acknowledged that some watersheds, lakes, and streams have been acidified as a result of acidic deposition and that others have adequate buffering as a result of geological and soil conditions, so that they are not subject to significant effects from acidic deposition. Therefore the concern about aquatic effects is focused on those regions or watersheds which have relatively low buffering capacity. These sensitive regions have been mapped in detail by NAPAP for the United States and by Canadian governmental organizations for Canadian resources.

My testimony presents quantitative information about current chemical status and future projections for lakes and streams in sensitive regions, based on NAPAP-sponsored research. The quantitative information is summarized in the following seven questions and responses.

Question 1: Are there acidic lakes or streams in the United States?

Yes. Surveys conducted by NAPAP describe the numbers of chronically acidic and sensitive lakes and streams in the different regions studied in the National Surface Water Survey. These regions are identified in

Figure 1 and the percentages of acidic[1] and sensitive[1] systems are summarized in Tables 1 through 3.

Question 2: How many of these acidic lakes and streams result from acidic deposition?

In the Northeast and the Southeast outside of Florida, I believe most of the acidity in acidic and sensitive surface waters comes from acidic deposition. Lake sediment cores also provide independent information suggesting acidification due to acidic deposition. In other regions, such as Florida and the upper Midwest, the contribution of acidic deposition to total acidity is smaller.

Question 3: Could this situation become worse?

Yes. With deposition continuing at current levels, streams could acidify in the Southern Blue Ridge Region where now none are acidic. Although the results are not yet complete, projections indicate that more acidic streams are possible in the mid-Appalachian region as well. In the Northeast, minimal changes are projected to occur at current levels of deposition according to best estimates from model projections.

Question 4: Will reductions in emissions help?

Yes. According to our model projections, reductions in deposition would result in improved water quality in acidic lakes and streams in the Northeast and could limit or prevent deterioration in the Southern Blue Ridge Region. I expect our projections will show that reducing deposition will result in fewer acidic lakes and streams in the mid-Appalachian region as well. These results will be complete next spring.

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[1]Acidic waters are defined as those having acid neutralizing capacity (ANC) less than zero. Sensitive waters are defined as those having ANC above zero but less than 50 μeq/L.

FIGURE 1

NAPAP

# Regions of the National Surface Water Survey

Table 1. Estimated percentages of target lakes relative to selected reference values of pH and ANC for the regions and subregions of the lake surveys-Phase 1[1].

| Subregion[2] and Regions[2] | pH | | | ANC (μeq/L) | | | |
|---|---|---|---|---|---|---|---|
| | ≤5.0 | 5.0 to 5.5 | ≤6.0 | ≤0 | ≤50 | ≤100 | ≤200 |
| 1A Adirondacks | 10 | 10 | 27 | 11 | 36 | 47 | 71 |
| 1B Catskills/Poconos | 1 | 5 | 8 | 5 | 13 | 19 | 39 |
| 1C Central New Eng. | 2 | 6 | 13 | 2 | 18 | 44 | 68 |
| 1D Southern New Eng. | 5 | 5 | 15 | 5 | 22 | 32 | 67 |
| 1E Maine | 1 | 1 | 5 | 1 | 11 | 34 | 67 |
| 1 Northeast | 3 | 5 | 13 | 5 | 19 | 35 | 60 |
| 2A NE Minnesota | 0 | 0 | 1 | 0 | 4 | 21 | 57 |
| 2B Upper Penn of MI | 9 | 4 | 18 | 10 | 19 | 29 | 42 |
| 2C No. Central WI | 2 | 9 | 28 | 3 | 41 | 50 | 57 |
| 2D Upper Great Lakes | 0 | 0[3] | 4 | 0 | 10 | 18 | 31 |
| 2 Upper Midwest | 2 | 2 | 10 | 2 | 15 | 26 | 41 |
| 3A So. Blue Ridge | 0 | 0 | 0[1] | 0 | 1 | 11 | 34 |
| 3B Florida | 12 | 8 | 33 | 22 | 35 | 51 | 55 |
| 4A Sierra Nevada | 0 | 0 | 1 | 0 | 37 | 70 | 87 |
| 4B Cascades, Olympics | 0 | 0 | 2 | 0 | 20 | 40 | 72 |
| 4C No. Rockies | 0 | 0 | 0 | 0 | 13 | 34 | 51 |
| 4D Central Rockies | 1 | 1 | 1 | 0[1] | 7 | 46 | 78 |
| 4E So. Rockies | 0 | 0 | 0 | 0 | 5 | 18 | 39 |
| 4 Mountainous West | 0[1] | 0[1] | 1 | 0[1] | 17 | 43 | 67 |

[1] Greater than 4 hectares ha and less than 2000 ha for regions 1, 2 and 3; greater than 1 ha and less than 2000 ha for region 4.
[2] See Figure 1 for map of regions and subregions.
[3] Greater than 0.0 but less than 0.5.

Table 2. Population Estimates of the Combined Length (km) and Percentage of Target Stream Reaches[1] with Spring Baseflow pH Less than Reference Values.

| Subregion | pH ≤ 5.0 | | pH ≤ 5.5 | | pH ≤ 6.0 | | Total Length |
|---|---|---|---|---|---|---|---|
| | Length | % | Length | % | Length | % | (km) |
| Poconos/Catskills | 550 | 3.6 | 906 | 6.0 | 1,354 | 8.9 | 15,144 |
| N. Appalachians | 1,424 | 6.6 | 1,870 | 8.6 | 3,044 | 14.0 | 21,738 |
| Valley & Ridge | 257 | 0.8 | 1,937 | 5.9 | 4,116 | 12.6 | 32,687 |
| MA Coatsal Plain | 3,147 | 7.8 | 9,565 | 23.7 | 18,707 | 46.4 | 40,296 |
| S. Blue Ridge | * | * | * | * | * | * | 9,036 |
| Piedmont | * | * | * | * | 2,390 | 7.1 | 33,531 |
| S. Appalachians | * | * | 313 | 1.4 | 920 | 4.2 | 21,892 |
| Ozarks/Ouachitas | * | * | 410 | 1.8 | 2,437 | 10.8 | 22,480 |
| Florida | 522 | 13.6 | 1,708 | 44.4 | 2,828 | 73.5 | 3,848 |
| SUBTOTALS | | | | | | | |
| Region | | | | | | | |
| Mid-Atlantic (MA) | 5,378 | 4.9 | 14,277 | 13.0 | 27,221 | 24.8 | 109,865 |
| Interior MA | 2,231 | 3.2 | 4,712 | 6.8 | 8,514 | 12.2 | 69,569 |
| Southeast (SE) | 522 | 0.6 | 2,431 | 2.7 | 8,576 | 9.5 | 90,787 |
| Interior SE | * | * | 723 | 0.83 | 5,747 | 6.6 | 86,939 |
| Total NSS-I | 5,900 | 2.9 | 16,708 | 8.3 | 35,797 | 17.8 | 200,652 |

* No samples observed below this reference value; estimated percentage is less than 1%.

[1] The target population is estimated as 57,000 stream reaches with a combined length of 200,000 km. Target stream reaches may be described as small to mid-size streams with drainage areas of approximately 0.2 $km^2$ at the upstream end. Streams typically have widths of 1 to 6 meters and are between 0.1 to 0.5 meters deep.

Table 3. Population Estimates of the Combined Length (km) and Percentage of Target Stream Reaches[1] with Spring Baseflow ANC Less than Reference Values.

| Subregion | ANC ≤ 0 | | ANC ≤ 50 | | ANC ≤ 200 | | Total Length |
|---|---|---|---|---|---|---|---|
| | Length | % | Length | % | Length | % | (km) |
| Poconos/Catskills | 543 | 3.6 | 1,606 | 10.6 | 5,489 | 36.2 | 15,144 |
| N. Appalachians | 1,524 | 7.0 | 3,713 | 17.1 | 12,935 | 59.5 | 21,738 |
| Valley & Ridge | 257 | 0.8 | 2,111 | 6.5 | 12,811 | 39.2 | 32,687 |
| MA Coatsal Plain | 2,527 | 6.3 | 9,636 | 23.9 | 21,091 | 52.3 | 40,296 |
| S. Blue Ridge | * | * | 706 | 7.8 | 7,084 | 78.4 | 9,036 |
| Piedmont | * | * | 2,390 | 7.1 | 13,554 | 40.4 | 33,531 |
| S. Appalachians | 117 | 0.5 | 763 | 3.5 | 6,130 | 28.0 | 21,892 |
| Ozarks/Ouachitas | * | * | 205 | 0.9 | 15,092 | 67.1 | 22,480 |
| Florida | 461 | 12.0 | 2,356 | 61.2 | 2,939 | 76.4 | 3,848 |
| SUBTOTALS | | | | | | | |
| Region | | | | | | | |
| Mid-Atlantic (MA) | 4,851 | 4.4 | 17,067 | 15.5 | 52,327 | 47.6 | 109,865 |
| Interior MA | 2,324 | 3.3 | 7,431 | 10.7 | 31,235 | 44.9 | 69,569 |
| Southeast (SE) | 578 | 0.6 | 6,420 | 7.1 | 44,799 | 49.3 | 90,787 |
| Interior SE | 117 | 0.1 | 4,064 | 4.7 | 41,860 | 48.1 | 86,939 |
| Total NSS-I | 5,429 | 2.7 | 23,487 | 11.7 | 97,125 | 48.4 | 200,652 |

* No samples observed below this reference value; estimated percentage is less than 1%.

[1] The target population is estimated as 57,000 stream reaches with a combined length of 200,000 km. Target stream reaches may be described as small to mid-size streams with drainage areas of approximately 0.2 $km^2$ at the upstream end. Streams typically have widths of 1 to 6 meters and are between 0.1 to 0.5 meters deep.

Question 5: What is the extent of these improvements?

In the Northeast, the models project that a 30% reduction in deposition will result in approximately half of those lakes which are currently acidic becoming nonacidic[2]. More specific information concerning projections for the Northeast and Southern Blue Ridge Region and their associated uncertainties is found in Tables 4 and 5. We expect that alkalinity would increase in the Mid-Appalachian Region. However, we cannot at this time project the extent and timing of these improvements. Our best estimates will be included in the Final Assessment.

Question 6: How long will it take for improvements to occur?

Chemical responses in the Northeast will begin to occur within one decade after emissions are reduced. Chemical responses in the mid-Atlantic and Southern Blue Ridge Regions which have greater sulfur accumulation capacity, will take several decades.

Question 7: How sure are you of your answers?

We are very sure of the current status of acidic and sensitive lakes and streams. We are less certain regarding our projections of future conditions. For example, there are significant uncertainties about the role that watershed mineral processes, organic acids and nitrates may play in the acidification and recovery processes. Determining the precise percentage of acidic waters due wholly, or in part, to acidic deposition carries with it scientific and statistical uncertainties. At present, the extent and impact of acidic episodes such as spring snowmelt and severe summer storms are uncertain but may subject surface waters and aquatic biota to periodic acidic stress. Work is underway to compare aquatic model projections with field observations to evaluate our ability to make projections. Although trends are evident in these projections, the effects of increased, constant, and decreased

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[2]The estimate is 75 lakes projected to become nonacidic, calculated as 162 lakes currently acidic minus 87 lakes remaining acidic after 50 years. See Table 4 for data and discussion of uncertainty limits. The projections do not include small (<4 ha) lakes expected to behave simiarly to the lakes in the target population.



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Table 4. Lakes in the NE Projected to have ANC Values <0 and <50 µeq/L for Constant and Decreased Sulfur Deposition[1,2].

| Time from Present (yr) | | Constant Deposition ANC <0 | Constant Deposition ANC <50 | Decreased Deposition ANC <0 | Decreased Deposition ANC <50 |
|---|---|---|---|---|---|
| 0 | #[3] | 162[4] | 880[4] | 162[4] | 880[4] |
| | % | 5 | 27 | 5 | 27 |
| 20 | # | 161 (245) | 648 (319) | 136 (230) | 621 (313) |
| | % | 5 (8) | 20 (10) | 4 (7) | 19 (10) |
| 50 | # | 186 (251) | 648 (329) | 87 (237) | 586 (332) |
| | % | 6 (8) | 20 (10) | 3 (7) | 18 (10) |

[1] Projections are based on 123 lake/watersheds (>4 ha) successfully calibrated by the Model of Acidification of Groundwater in Catchments (MAGIC).

[2] The constant deposition scenario was at current levels. The decreased deposition scenario was held at current levels for 10 years then decreased linearly for 15 years to a level 30% below current deposition and then held constant.

[3] # is the number of lakes; % is percent of the target population of 3,227 lakes; the numbers in parentheses indicate the 95 percent confidence estimates, e.g. 161 ± 245.

[4] Indicates estimate from the National Surface Water Survey (NSWS) Phase 1 sample for the same 123 lakes; target population = 3,227 lakes.

Table 5. Streams in the Southern Blue Ridge Region Projected to have ANC Values <0 and <50 μeq/L for Constant and Increased Sulfur Deposition[1,2].

| Time from Present (yr) | | Constant Deposition | | Increased Deposition | |
|---|---|---|---|---|---|
| | | ANC <0 | ANC <50 | ANC <0 | ANC <50 |
| 0 | #[3] | 0[4] | 3[4] | 0[4] | 3[4] |
| | % | 0 | 0.2 | 0 | 0.2 |
| 20 | # | 0 | 187 (310) | 0 | 187 (314) |
| | % | 0 | 14 (23) | 0 | 14 (24) |
| 50 | # | 129 (295) | 203 (333) | 159 (291) | 340 (359) |
| | % | 10 (22) | 15 (25) | 12 (22) | 26 (27) |

[1] Projections are based on 30 stream/watersheds successfully calibrated by the Model of Acidification of Groundwater in Catchments (MAGIC).

[2] The constant deposition scenario was at current levels. The increased deposition scenario was held at current levels for 10 years then increased linearly for 15 years to a level 20% above the current level then held constant.

[3] # is the number of streams; % is percent of the target population of 1,323 stream reaches; the numbers in parentheses indicate the 95 percent confidence estimates, e.g. 187 ± 314.

[4] Indicates estimate from the National Surface Water Survey (NSWS) Pilot Stream Survey sample for the same 30 streams; target population = 1,323 stream reaches.

deposition are not always statistically significant[3]. The quantitative estimates given here provide our best estimates, based on over four years of data collection and intensive analysis.

Surface Water Survey Information

Since 1984, NAPAP has conducted extensive surveys of lakes and streams. Figure 1 indicates the areas studied in the National Surface Water Survey (NSWS). Although acidic and sensitive surface waters may occur outside the regions studied, the majority occur within these regions. The chemical status of the lakes and streams in these regions is summarized in Tables 1 to 3.

The percentage of eastern and midwestern lakes and streams that are acidic varies from region to region. Similarly, a further percentage of these lakes and streams are highly sensitive to acidification. Proportions of acidic and sensitive surface waters within defined subregions are considerably higher (e.g., Adirondacks with 11% acidic and 36% sensitive) or lower (e.g., Maine with 1% acidic and 11% sensitive) than the regional values reported in Tables 1 to 3. In addition, lakes less than 4 ha were not sampled in the Eastern Lake Survey. In some areas, for example the Adirondacks, the percentage of acidic small lakes (less than 4 ha) is likely to be greater than the percentage of large lakes. The Adirondack Lake Survey Corporation has developed useful data for the Adirondack region (including small lakes). The Adirondack Lake Survey Corporation data indicate that 27% of the Adirondack lakes are acidic. This will be fully reported in the NAPAP Integrated Assessment. While survey information cannot by itself be used to establish the cause of the chemical status of a water body, it provides an estimate of the current number of acidic and sensitive surface waters and serves as a reference point for future monitoring. Biological impacts are expected in acidic and some sensitive waters.

[3]Refer to Tables 4 and 5 for more information on confidence intervals.

Projections of Change in Surface Water Status

Regarding future status of surface waters, indications are that the steady-state hypothesis is valid in the Northeast, i.e., taken as a region, watersheds exhibit an approximate balance between sulfur inputs and outputs. This suggests that, in such areas, changes in sulfur inputs will more directly influence surface water chemistry. In the Southern Blue Ridge Region, systems are not in balance and soils are still adsorbing sulfur[4]. The Mid-Atlantic Region appears to be intermediate in its current ability to retain sulfur (Figure 2). These conditions lead to the following conclusions concerning future changes.

In the Northeast, under constant deposition, little chemical change is expected because systems are at steady state. Under a 30% decrease in deposition, approximately half of the currently acidic lakes will improve chemically. This response will not be immediate since the watersheds may release previously retained sulfur into surface waters, causing a limited number of systems to further acidify. Biological recovery (e.g., self-reproducing fish populations) will require additional time; but stocking would result in rapid reestablishment of depleted sport fish after chemical recovery.

In the Southern Blue Ridge Region there are presently no acidic lakes. At current levels of deposition, projected changes could occur after the sulfate adsorption capacity of watersheds is exhausted, within 20 to 50 years. The projected number of systems becoming acidic under constant deposition is 10%[5].

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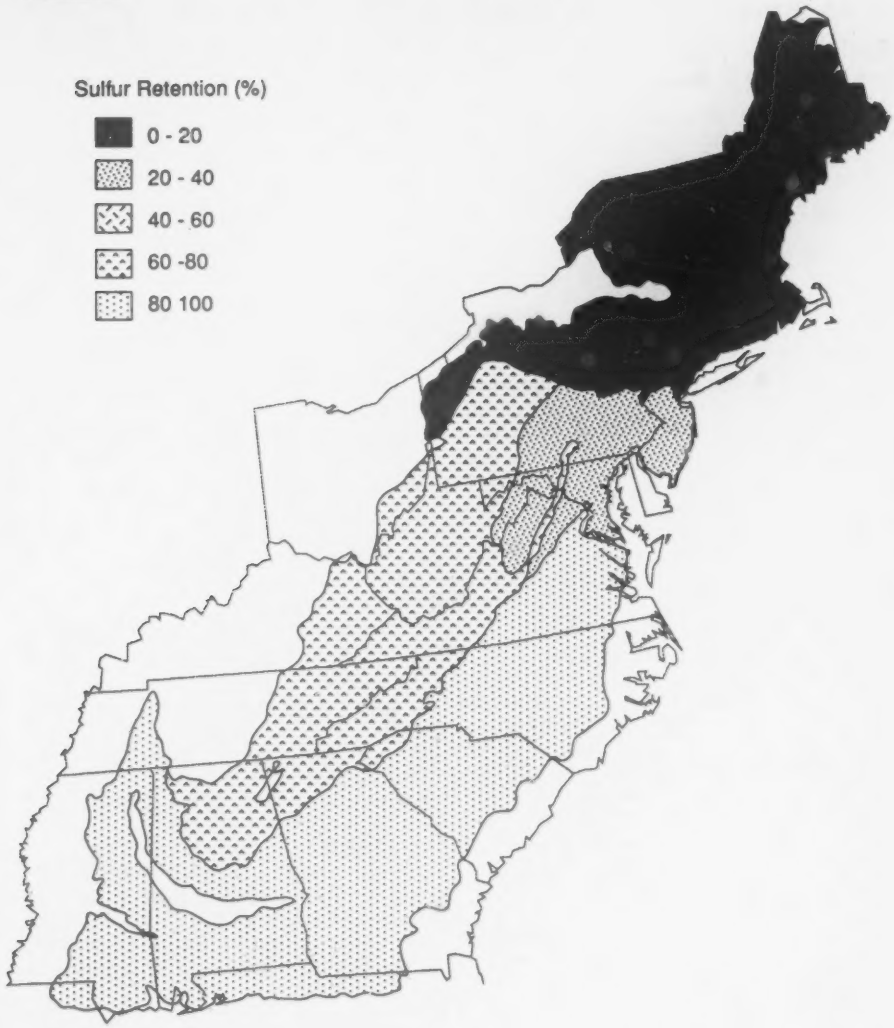
[4]An estimate of the current status of watersheds with respect to sulfate retention and storage capacity is important because any sulfate that is not retained and passes into surface waters will be accompanied by calcium and magnesium from the soils or, if there are insufficient amounts of these, by hydrogen (acidity) and aluminum.

[5]The 95% confidence interval on this estimate is $\pm$15%. Thus, our best estimate is that 10% of the systems acidify. The number may be as large as 25%. Alternatively, models project that 5% of the systems increase in ANC.

# Figure 2. Median Percent Sulfur Retention



With a 20% increase in deposition, we project 12%[6] may become acidic. Biological impacts would generally follow as waters become acidic. Decreased deposition would likely decrease the rate at which acidification occurs.

The current status of surface waters in the Mid-Atlantic Region, including estimates of the numbers of acidic and sensitive systems, is known (Tables 2 and 3). Projections of future conditions are underway. Significant research for this region is being completed and will be included in the NAPAP 1990 Assessment. This research was undertaken when NAPAP's National Stream Survey showed that sensitive surface waters occurred in some of the mid-Atlantic subregions. Additional analyses suggest that some acidification may occur within a few decades.

Effects on Forests

As a result of NAPAP research and other studies conducted during the past several years, significant advances have been made in evaluating the hypotheses on forest effects. Synthesis of the most recent information has resulted in the current view summarized as follows: (1) acidic deposition appears to intensify the effects of natural stresses upon red spruce at eastern high elevation locations; (2) other than for red spruce, extensive surveys of forest condition have indicated no evidence of widespread forest decline in North America related to acidic deposition; (3) ozone adversely affects forest health in parts of southern California, and possibly in some southeastern regions; and (4) cumulative effects of acidic deposition may reduce the fertility of some forest soils within a period of approximately 50 years.

Trees respond to a wide range of natural and anthropogenic stresses throughout their life cycles. Because of the long life cycle of forest trees (decades to centuries), the effects of these stresses accumulate over time and compound

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[6]The 95% confidence interval on this estimate is ±16%. Thus, our best estimate is that 12% of the systems acidify. The number may be as large as 28%. Alternatively, models project that 4% of the systems increase in ANC.

the problems of isolating the influences of air pollution, and more specifically acidic deposition, from other sources.

Two mechanisms of potential damage to forests from acidic deposition are usually considered: (1) direct impacts on the trees, and (2) indirect impacts due to alterations in soil chemistry. Direct impacts are more likely at high than at low elevations because forests are exposed to severe natural stresses as well as frequent exposure to cloud water containing acids often at higher concentrations than observed in rain. At some locations, ozone exposures are also greater at the higher elevations. Indirect impacts of acidic deposition due to soil chemical changes are of concern because such processes may be cumulative over large areas, with impacts becoming apparent over long time periods (i.e., decades). Soils at high elevations are often thin and poorly buffered, and these forests may also be the first to experience indirect impacts.

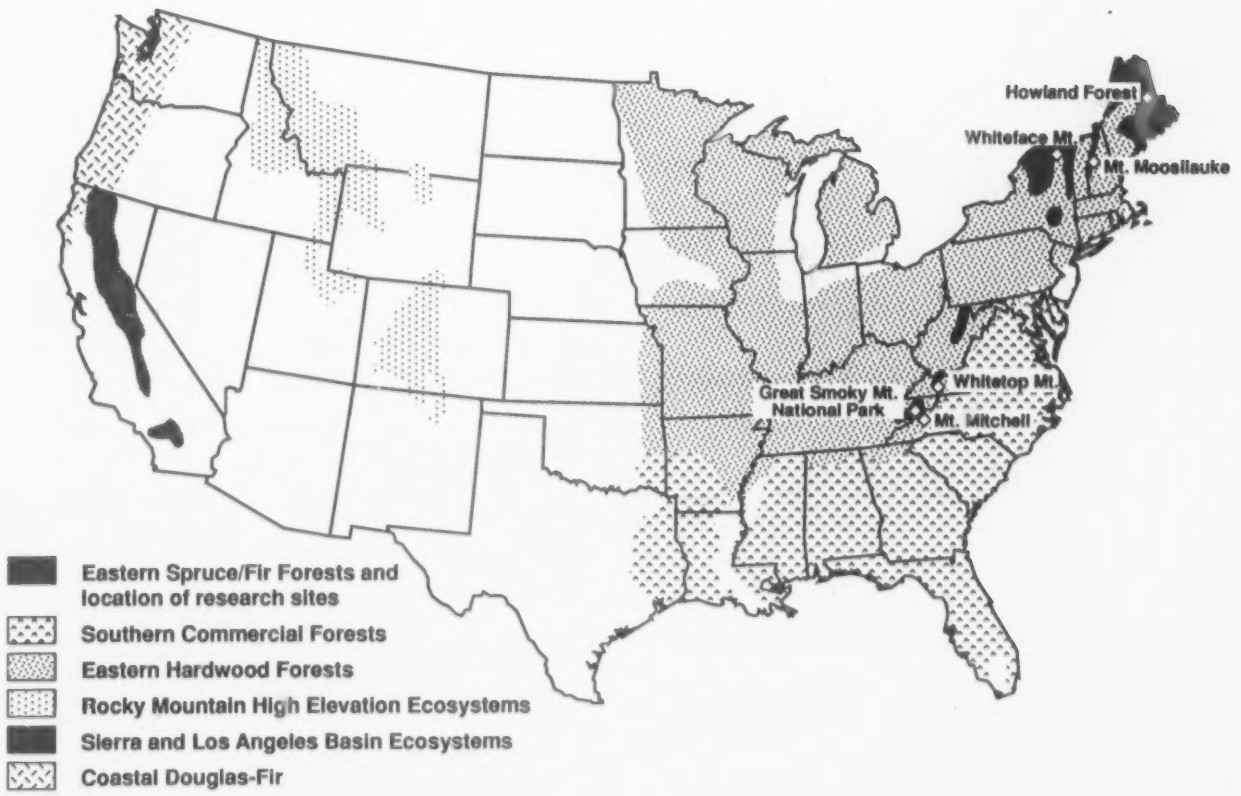
Figure 3 illustrates the range of the spruce-fir forests in the eastern United States, and indicates the locations of the NAPAP-sponsored spruce-fir research. Regions of other major forest types that have been studied in the NAPAP Forest Response Program are also shown. Decreased growth and increased mortality have been observed in some high elevation (above 2600 feet) stands of spruce-fir in the Northeast. In the Southeast, the spruce-fir stands are above 4500 feet and decreased growth has been observed in these stands. Several natural stresses are related to these declines, and acidic deposition from cloud water may intensify the effects of the natural stresses. Research aimed at confirming the possible importance of the acidic deposition stresses is continuing. Although the extent of these high elevation stands is limited (about 6% of the total area of eastern spruce-fir forests are at high elevations) they represent a unique ridge-top ecosystem.

Effects on Agricultural Crops

Research has established that there is no measurable and consistent adverse crop yield response from the direct effects of acidic rain at ambient levels

NAPAP

# Figure 3. Research on Effects on U.S. Forests



in North America. Thus, the acidic deposition impact on regional crop production in the United States is considered to be negligible. An evaluation of the nutritional enrichment of some agricultural soils through the input of sulfur and nitrogen from acidic deposition indicates indirect benefits associated with decreased fertilizer requirements. Controlled studies suggest that on rare occasions fog acidity levels may potentially be high enough in the greater Los Angeles area to cause visible symptoms and thereby reduce the marketability of a few sensitive crops, such as strawberries. Nitrogen compounds are important constituents of such acidic fogs.

Average ambient concentrations of sulfur dioxide and nitrogen dioxide gases in most agricultural areas in the United States are not high enough or at elevated levels frequently enough to cause adverse effects on crop production on a regional scale. Effects may occur in local situations close to major sources (i.e., within a few kilometers). In contrast, controlled studies indicate that ambient levels of ozone in many regions of the United States are sufficient to reduce the yield of many agricultural crops.

Effects on Materials

Acidic deposition increases the rate of deterioration of some materials (e.g. galvanized steel and carbonate stone), some surface coatings (e.g. carbonate based paints) and some cultural resources (e.g. statues). The relationships between acidic deposition rates and deterioration rates for various materials have been studied in the NAPAP program. However, there are serious limitations in developing representative data and interpretive methods to isolate and inventory acidic deposition effects on exposed materials. Therefore, no generally accepted regional or national estimates of materials effects resulting from acidic deposition are currently available.

Deterioration of some exposed materials, partially attributable to acidic deposition, is recognized in major urban areas. Because of the large economic and cultural value of these materials, reduction of acidic deposition could have significant benefits in some cases. However, two factors limit the

potential materials benefits which may result from reduction of acidic deposition levels: (1) acidic deposition is only one element of air pollution exposure for materials, particularly in major urban areas, where most of the nation's materials and cultural resources are located. Reductions in urban air pollution levels will likely create the largest materials benefits. (2) Maintenance and reconstruction activities are often undertaken for reasons unrelated to possible acidic deposition effects. Thus, at present, economic impacts due to materials deterioration cannot be estimated directly from the physical dose-response information. In its final (1990) assessment NAPAP will report bounding estimates of the materials benefits related to reductions in acidic deposition.

Economic Valuation of Benefits

Economic valuation methods have not been sufficiently tested for the full range of effects categories to support a comprehensive benefit-cost evaluation of acidic deposition control approaches. NAPAP is developing economic estimates of benefits in several categories, and will report them in its final assessment. Because of the limitations in currently available valuation methods, NAPAP has adopted three categories of benefits to compare between various control approaches. These categories of benefits are: (1) health-related benefits; (2) economically-evaluated benefits -- including market estimates such as productivity in commercial forests and behavior-based estimates such as for recreational fishing in lakes; and (3) conservation or ecological benefits -- including preservation of culturally important materials, remote lakes, and mountain forests for which obtaining credible economic estimates is particularly difficult.

Atmospheric Processes and Deposition

From 1979 to 1986, the majority of the wet deposition monitoring stations in the eastern United States showed an average reduction of the wet deposition of sulfate of 14 percent, although the trend was not statistically significant. The geographic regions of maximum deposition of sulfates and nitrates has

remained relatively constant since 1983, and includes western Pennsylvania and New York, northern West Virginia, eastern Ohio, and Southwestern Ontario. In 1986 these maximum values were about 35 kg/ha for sulfates and 22 kg/ha for nitrates. This region also includes the region of highest rainfall acidity (pH <4.2).

Although the annual wet deposition of sulfate has decreased as the emissions of $SO_2$ have decreased since the 1970's, no apparent trend in the acidity of rainfall has been detected. Although this may be due in part to the inability of instrumentation to detect small changes in acidity, other factors such as neutralizing substances like calcium, ammonia, and oxidants in the atmosphere, should also be considered when evaluating patterns and trends of acidic deposition.

One of the major scientific issues addressed by NAPAP is the relationship between emission changes and deposition changes. Because of complex atmospheric reactions, percentage reductions in emissions may not result in similar percentage reductions in deposition at a particular location. In order to assess the importance of this non-linear relationship, NAPAP has devoted considerable effort to modeling the relationship between emissions and deposition through development of the Regional Acid Deposition Model (RADM).

Preliminary results from a few cases of this model suggest that non-linearity for wet sulfate deposition can occur in and near the region of maximum emissions density. The region of non-proportionality between sulfur dioxide emissions and wet sulfate formation may extend as far as 700 km downwind (generally to the north and east) of the major emission region of the Ohio River Valley. This suggests that emissions changes in the Ohio River Valley and eastern United States may result in less than proportional reductions in wet deposition in the downwind region. However, dry deposition, an important part of the total deposition, is expected to change more linearly with emission changes.

**Control Techniques**

Near-term reductions in sulfur dioxide emissions can be achieved using currently available techniques including fuel substitution, physical coal cleaning in those situations where this is not already employed, and flue-gas desulfurization (FGD or "scrubbing"). In most cases, switching from high sulfur to low sulfur coal can substantially reduce sulfur dioxide emissions. Physical coal cleaning achieves 10-30% sulfur removal, and the current generation of FGD achieves 70-90% sulfur removal. Higher efficiencies can be achieved with the addition of special additives (e.g., adipic acid) to the sorbent. Low nitrogen oxide burners and combustion modification techniques are available to reduce nitrogen oxide emissions from most uncontrolled coal-fired boilers by 25% to 50% in some cases. In addition, lime or lime hydrate injection into the boiler or ducts, may be an effective means of controlling sulfur dioxide.

A number of innovative advanced combustion technologies are under development with the aim of achieving either higher removal efficiencies at similar cost to conventional technologies or similar removal efficiencies at lower cost.

- Integrated gasification combined cycle (IGCC) plants can potentially achieve over 99% removal of sulfur dioxide emissions and over 95% removal of nitrogen oxide emissions. This technology has been demonstrated. However, the 99% sulfur dioxide removal was achieved at higher cost than conventional FGD. Hot gas cleanup, currently unproven in a fully-integrated, high-efficiency system at a commercial scale, will be required to improve the costs.

- Atmospheric fluidized bed combustion (AFBC) can achieve 90-95% removal of sulfur dioxide emissions and 70-80% removal of nitrogen oxide emissions and is in the commercial demonstration phase.

- o Pressurized fluidized bed combustion (PFBC) is entering the commercial-scale demonstration phase, with prospects of higher removal and conversion efficiencies (at higher costs) relative to AFBC.

Advantages of these clean coal technologies over flue gas desulfurization can include: improved energy efficiency (greater kilowatt output per ton of coal consumed), lower emissions of carbon dioxide (a greenhouse gas), significant removal of nitrogen oxide emissions, more manageable wastes, possible use of poor-quality coals, and potential for future export of both clean coal technologies and coal. Wide deployment of clean coal technologies in lieu of conventional techniques can be initiated only when adequate experience from full scale commercial demonstrations is available.

Schedule of NAPAP Reports

NAPAP will publish its assessment reports at various scheduled dates in the next twelve months, as described in the Plan and Schedule for NAPAP Assessment Reports, released in January 1989. In view of current Congressional interest in the NAPAP findings, we are providing all reports as quickly as practical, consistent with assuring thorough review processes for these documents. For the information of the Subcommittee NAPAP has scheduled completion of its reports as follows:

(1) Findings Update -- November 1989

This will briefly summarize principal new technical information which has become available in 1988 and 1989.

(2) State-of-Science and State-of-Technology (SOS/T) Reports (Public review drafts) -- December 1989

These 28 major reports have been in development throughout 1989, in accord with the January 1989 NAPAP Assessment Plan. These drafts are currently undergoing peer review and interagency review, and are planned

for release in early December. The draft reports will be publically reviewed during the NAPAP International Conference scheduled for February 1990.

(3) NAPAP International Conference on Acidic Deposition -- February 11-16, 1990

This conference will focus on critical review of NAPAP's 28 SOS/T Reports. Preliminary conference registrations have already been received from more than 600 scientists and other representatives of government, nongovernment and private organizations from over 30 countries.

Final revisions to these reports, incorporating the critiques discussed at the International Conference and the latest NAPAP-sponsored research data, will be completed by mid-1990.

(4) Integrated Assessment Report -- review draft in mid-1990, and final information by September 1990

NAPAP's Integrated Assessment, responding to all of the questions posed in the January 1989 NAPAP Assessment Plan, will be available for review beginning in mid-year and completed by September 1990.

PART 2 - KEY ACCOMPLISHMENTS DURING THE PROGRAM

Our scientific understanding of the causes, effects, and control approaches for acidic deposition has increased considerably over the past nine years. Work performed within NAPAP has greatly broadened the information available to evaluate acidic deposition, and has advanced our understanding of some of the fundamental ecological and physical processes impacted by our nation's use of energy. The following comments briefly note some of the principal contributions of NAPAP in two categories: (1) improvements in scientific

knowledge and analytical tools, and (2) development of assessment methodology for complex environmental issues.

## Improvements in Scientific Knowledge and Analytical Tools

*Aquatic Effects*

- The extent, location, and chemical characterization of low pH and sensitive (low acid neutralizing capacity) lakes and streams in the eastern U.S. and lakes in the western U.S. have been established.

- Models to project future chemical changes for alternative deposition scenarios have been created and are being tested using data from a watershed manipulation project in Maine.

- Methodologies to sample representative surface waters and watersheds and project those results to regional populations have been developed.

- Preliminary estimates of the extent, magnitude, frequency, and duration of episodic acidic stresses to aquatic systems (e.g., from snowmelt or intense rainstorms) are being completed.

- The differentiation between natural and anthropogenic acidification has been evaluated by analysis of historical information using sediment cores.

- Information on the physiological mechanisms of damage to fish from acidic waters has been developed to project biological responses associated with changes in the chemistry of surface waters.

- Selected aquatic effects mitigation techniques have been evaluated.

*Terrestrial Effects*

- Recently completed national surveys of forest condition have established credible and comparable data bases for the first time. These data bases provide baseline information for future evaluations of forest status in the United States.

- Standard guidelines have been established for diagnosing injury to eastern forest trees caused by air pollution (including ozone), pathogens, insects, and abiotic stresses.

- Scientific consensus that agricultural crops are not damaged by acidic deposition has been achieved by eliminating the major uncertainties in this area through research and assessment.

- Continued studies have allowed further refinements of crop response functions for more accurate estimations of agricultural losses from ozone.

- Innovative techniques for studying the effects of stress on plants have been established and have provided important information on basic plant processes that will prove useful for many types of scientific inquiries.

*Effects on Materials*

- Better identification of the types of materials most susceptible to physical damage from acidic deposition has been made.

- Dose-response functions for several materials have been established by laboratory experiments and controlled field exposures.

- The economic importance of the susceptible materials and consumer maintenance practices associated with their use has been studied.

*Emissions*

- The first comprehensive inventory of natural and anthropogenic emissions associated with fossil fuel combustion was established for 1980. The 1980 inventory was updated for 1985 emission sources, using improved estimation methodology, data collection techniques, and quality control procedures.

- An integrated emissions modeling set, allowing projections of future emissions expected to result from changes in population, economic activity and control technology costs, has been developed. This model set is being used to project control costs, fuel mix, labor impacts and emission levels for several future scenarios.

*Source-Receptor Relationships*

- Advances in monitoring networks, improvements in emissions inventories and trends, and the considerable advances in atmospheric modeling technology made in NAPAP-sponsored research projects will allow us to assess source-receptor relationships with a much higher degree of confidence than in the early 1980's.

- The most comprehensive model of atmospheric processes associated with acidic deposition, the Regional Acid Deposition Model (RADM), was developed by NAPAP and is being used as both a research tool and an assessment tool. RADM will significantly improve our capability to analyze a range of regional and national scale atmospheric chemistry issues.

*Control Measures*

- Cost information has been gathered from 15 site-specific retrofit emission reduction studies in Ohio, Kentucky and TVA which developed

comparative information on FGD, coal cleaning, coal switching and other removal approaches. This information will be useful in developing realistic cost information for a number of control approaches.

- The current status of available and developing control technology has been analyzed. This includes improvements in FGD (scrubber) technology which yield higher removal rates and increased energy efficiency as well as developments in clean coal technologies.

*Economic Analyses*

- NAPAP has implemented an economics research and assessment program to value those acidic deposition-related effects to which economic methods can be credibly applied. This includes market effects (forests, crops, materials) as well as nonmarket effects (recreational fishing). Economic valuation of benefits will be reported where feasible in the NAPAP Integrated Assessment.

- NAPAP has developed the capability to estimate both the direct costs associated with emissions reductions and the indirect costs of control programs such as employment or GNP impacts.

**Development of an Integrated Assessment Methodology**

In its final two years, NAPAP has shifted emphasis from research to assessment activities. A comprehensive Assessment Plan was developed to promote wide communication of the assessment results, and to expedite general use of the information. NAPAP's assessment methodology provides a framework for continuing evaluation of the effectiveness of new emission controls during the 1990's. The NAPAP Integrated Assessment methodology also provides a working example for other important environmental assessments.

- NAPAP's final assessment consists of two parts: (1) a series of 28 State-of-Science/Technology (SOS/T) Reports documenting comprehensive

technical information relevant to acidic deposition, and (2) an Integrated Assessment providing a synthesis of the technical information from the SOS/T Reports to assist policy-makers and the public in evaluating a wide range of questions concerning acidic deposition.

- o The NAPAP Integrated Assessment is structured around a series of key questions to present comparative analyses and costs associated with various emissions reduction scenarios. Scenarios reflect differences in scope, timing, and location of controls.

- o Scientific peer review, interagency review and open public review of the draft NAPAP reports are integral elements of the assessment methodology.

- o An Oversight Review Board consisting of widely recognized outside experts has been established to provide counsel on NAPAP's approach to reporting its Integrated Assessment findings.

PART 3 - CONTINUED DATA COLLECTION AFTER 1990

Your invitation requested my views on the potential use of continued data collection after the NAPAP mandate expires in 1990. In response to your question, three categories of longer-term information needs are noted: (1) trend information for key parameters, (2) continuation of data sharing among all relevant government agencies, and (3) special studies to address unresolved or emerging technical issues.

(1) Importance of long-term trend information.
Trend monitoring of acidic deposition itself, and the various effects of acidic deposition, provide "real world" confirmation of the predicted consequences of emissions changes. The NAPAP-sponsored studies have greatly expanded the information available about pollutant emissions, atmospheric processes, and environmental effects. Trend data collection can be much less extensive than the measurements associated with intensive studies. In the absence of follow-up trend information, much

of the value of NAPAP's intensive short-term studies would not be maintained.

(2) Continuation of data sharing among all relevant organizations. The NAPAP experience has demonstrated the advantages of sharing information gathering activity, as well as scientific analyses and reviews, among several organizations. NAPAP's reports have greatly benefitted from the interagency studies and technical reviews carried out at the federal level, and from collaboration with major state programs, such as the extensive lake surveys conducted by the Adirondack Lake Survey Corporation in New York State.

NAPAP is currently compiling a report summarizing the acidic deposition research and assessment activities being conducted by state, private, and other nongovernment organizations. We will forward this survey to the Subcommittee as soon as it is available, within 60 days. Many of the state environmental organizations have expressed their interest in having single-location federal coordination of acidic deposition studies during the next several years, to assure efficient planning of federal- and state-level technical studies.

(3) Special studies

The intensive NAPAP studies have provided the necessary information to address many of the key technical issues related to acidic deposition. Several unresolved technical issues remain. The decade of the 1990's will be particularly appropriate for such studies because regional emissions controls (i.e., as implemented in new legislation) would provide a unique natural laboratory for evaluation of the effects of emissions change. We consider the following technical areas to be important:

Emissions

- Further resolution of natural source emission estimates for nitrogen oxides and volatile organic compounds. In particular, better estimates of the variation of volatile organic compound emissions with season and latitude are needed. Significance: Natural sources of nitrogen oxides and volatile organic compounds constitute important components of the atmospheric budget of these acidic precursor pollutants. Accurate estimates of these emission rates are important in the formulation of regional control strategies.

Transport & Deposition:

- The completion of regional atmospheric model evaluation studies will improve the capability to determine the relationship between major sources and the resultant effects in specific regions. Significance: Further model evaluation and application will address more specific questions of importance in resolving issues such as the role of oxidants, source attribution, emissions trading, and effectiveness of control approaches.

- Continuation of non-urban air quality and deposition trend monitoring. Significance: These data are important for quickly verifying the air quality and deposition responses due to emissions reductions to measure the efficacy of controls.

Aquatic Effects:

- Continuation of long-term monitoring of surface waters is very important. Significance: Some surface waters have been impacted by acidic deposition. Verifying the predicted responses due to emission reductions is necessary to measure the efficacy of the controls implemented.

- The mathematical models for projecting watershed response to changes in deposition need further evaluation and development, especially for nitrogen and organic compounds. Significance: Information from fully verified watershed response models will help to evaluate the effectiveness of emissions reduction strategies.

- Continuing research on episodic acidification events (associated with spring run-off and severe storm events) is needed. Significance: Episodic pH depressions are of interest because of their potential effect on aquatic resources. Current projections of watershed response to emissions reductions do not consider episodic acidification.

Forest Effects:

- Completion of long-term forest response research, with emphasis on evaluation of response to multiple stresses, and continuation of surveys to monitor forest condition are needed. Significance: Evaluation of long-term forest response to multiple stresses, including ozone and acidic deposition, requires long-term field measurements.

Materials Effects:

- Continuing research is needed to distinguish local and distant source contributions. Significance: Since most of the nation's materials and cultural resources are located in urban areas, reductions in urban air pollution levels will likely create the largest materials benefits.

- Better damage functions are needed for several economically important materials, especially paints and other surface coatings. Significance: Damage functions for a greater range of materials will allow better economic estimates of materials impacts.

Mr. Chairman and members of the Subcommittee, this completes my testimony. I would be pleased to answer the questions you may have. Thank you again for the opportunity to provide this summary of the information being developed by NAPAP.

**STATEMENT OF**
**DR. COURTNEY RIORDAN**
**DIRECTOR, OFFICE OF ENVIRONMENTAL PROCESSES AND EFFECTS RESEARCH**
**OFFICE OF RESEARCH AND DEVELOPMENT**
**U.S. ENVIRONMENTAL PROTECTION AGENCY**
**BEFORE THE**
**SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION**
**OF THE**
**COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS**
**UNITED STATES SENATE**

October 5, 1989

Mr. Chairman, Members, staff and guests, thank you for the invitation to appear before the Subcommittee to discuss the scientific accomplishments of the federal acid rain research program, EPA's involvement in the program, and the direction of future research and monitoring activities beyond 1990.

Historical Perspective

In 1980, Congress passed the Energy Security Act (P.L. 96-294), which created the interagency National Acid Precipitation Assessment Program (NAPAP). NAPAP was established as a long-term, comprehensive program to investigate the causes and effects of acid deposition and to provide periodic assessments of the available scientific data. The program was given a ten year mandate, with annual reports of progress to Congress.

Over the past ten years the program has provided a wealth of information. Starting out with barely a foothold in understanding acid rain, we have now: (1) constructed and evaluated models to determine the relationships between changes in emissions and acid deposition, (2) evaluated the magnitude and extent of lake and stream acidity in sensitive regions, (3) developed models and predicted expected rates of change in the acidity of sensitive

lakes and streams, (4) further clarified the relationship between emissions and effects on high elevation forests and other types of forests, (5) established an ongoing network to monitor wet and dry deposition, and (6) determined the current levels and patterns of acid deposition. Interagency cooperation has been an essential ingredient to the progress made and innovative approaches required to pursue an effective acid deposition research program. From the outset, the program was designed to meet the ten-year sunset provision, culminating with a final assessment report. The final goal of the program will be achieved with the release of the 1990 Assessment Report to Congress.

Major Accomplishments

From 1980 through 1990, the federal agencies under the auspices of NAPAP will have spent over $500 million on acid deposition research. Of that amount, EPA's contribution will have been about $325 million. This investment has produced a wealth of information and advanced our ability to formulate policy and to understand the implications of policy decisions. Long-term environmental records, which were practically non-existent before NAPAP, are now established and models are available to help understand and predict future change.

The interagency process has been fundamental in providing an effective forum for planning, designing, implementing and evaluating the necessary research and monitoring activities. Without such coordination the research would have been piecemeal

and the results fragmented. Some of the areas where interagency cooperation and coordination were indispensable were the following:

- Development of inventories for emissions of sulfur dioxide ($SO_2$) and nitrogen oxides ($NO_x$) for 1980 and 1985 base years.
- Development of the Regional Acid Deposition Model (RADM) and implementation of a field program to evaluate RADM.
- Establishment and support of a nationwide wet deposition monitoring network comprised of 200 stations, and a 49-site dry deposition network.
- Determination of the chemical status of lakes and streams in regions of the country potentially sensitive to acid deposition, through the National Surface Water Survey.
- Advancements in the technology to develop mechanistic and empirical models of source - receptor relationships and effects to terrestrial, aquatic, and material resources and to design and conduct large-scale surveys of potentially affected resources.
- Description of the status and extent of forest damage other than by natural forest stand factors.
- Evaluation of the response of tree seedlings to experimental treatments of acid deposition and other pollutants in the laboratory and the field.
- Examination of the effects of acid deposition on major agricultural crops.
- Contribution to the information base on potential effects upon terrestrial, aquatic, and material resources of multiple pollutants, such as sulfur dioxide, nitrogen oxides, ozone, particulates, and heavy metals.
- Development of a theoretical dose - response function relating acid deposition to the corrosion of galvanized steel, etching of building stone, and development of methodologies and analytical techniques to assess damage to paint.

Currently, EPA scientists are playing a major role in preparing the State-of-Science/ Technology reports and Integrated Assessment for NAPAP.

Future Direction and Activities

Under the current schedule, the NAPAP Assessment will be released in September 1990. A core staff will remain until December 1990 to respond to questions about the Assessment. With the goals and objectives of NAPAP accomplished, much of EPA's acid rain research will be completed. The emphasis will shift from supporting research to supporting the implementation of an acid deposition control program, including the evaluation of control technologies.

EPA believes that certain research areas need to be continued beyond 1990 to provide scientific information for the EPA policy and regulation development process. Specific areas include the following:

- Emissions Inventories and Modeling. Inventories of emissions from man-made sources will continue to be developed, using improved and less costly methods. Models specific to major source sectors will be maintained and refined for use in analyzing cost-effective strategies.

- Atmospheric Modeling. RADM will be utilized as a predictive tool for analyzing different control scenarios and for providing information to assess future atmospheric, terrestrial and aquatic effects.

- Deposition Monitoring. Routine monitoring will be performed for deposition of sulfur dioxide, ozone and particulate sulfate and nitrate. This work will enable detection of changes in air quality and deposition as a result of implementation of a new emissions control program.

Given EPA's role as the lead federal agency in the policy arena, the work continuing in the Office of Research and Development (ORD) after 1990 will be in support of policy needs, including the Office of Air and Radiation's (OAR) implementation

of an acid rain control program. ORD also will support the preparation of a study on the effects of emissions reduction. The study, due in 2003, is included in the President's acid rain proposal. The analyses will use many of the models developed by NAPAP, which will be described and applied in the 1990 Assessment. Results from NAPAP also will help in conducting research and policy analyses on related issues, such as oxidants and nitrogen oxides.

Conclusions

The acid deposition research program conducted cooperatively across the federal government has produced a substantial body of scientific information on all facets of this complex environmental problem. NAPAP has been highly successful in achieving its fundamental goal to provide quality scientific information for the policy process. Major accomplishments in EPA's work in aquatic, terrestrial, materials, modeling and emissions technology have been achieved.

The needs of the program are shifting from supporting research to supporting the implementation of an acid rain control program, including monitoring and assessment of the impact of emission reductions. EPA believes the following activities should be continued to support policy decisions: emissions inventories and modeling, atmospheric transport and transformation modeling, and deposition monitoring. These activities, in particular, will provide sustained support to near- and long-term policy development and evaluation of control measures related to acid deposition and other atmospheric pollution problems.

STATEMENT OF

Milton Russell
Chairman, NAPAP Oversight Review Board

Before the

SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION
UNITED STATES SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

October 5, 1989

Mr Chairman and Members of the Committee:

I am pleased to accept your invitation to testify on the research program of the National Acid Precipitation Assessment Program as Chairman of the NAPAP Oversight Review Board. For identification purposes only, I am a Professor of Economics and Senior Fellow of the Energy, Environment and Resources Center of the University of Tennessee, Knoxville, and a Collaborating Scientist at Oak Ridge National Laboratory.

The Oversight Review Board was established by the Joint Chairs of NAPAP. The appointment letter (attached) from Chairman William K. Reilly stated:

> The principal responsibilities of the Oversight Review Board are to provide advice to NAPAP Management and the Joint Chairs Council regarding the quality, scientific integrity, credibility, and practicality of the many different parts of the NAPAP Final Assessment. This will require evaluation of NAPAP's approach to creating, reviewing, and publishing the following parts of the Final Assessment:
>
> -- State of Science/Technology Reports to be published as review drafts in November 1989 and in final versions in July 1990;
>
> -- Lay Summaries of the State of Science/Technology Reports to be published in 1990; and
>
> -- The Integrated Assessment to be published in September 1990.

He stated that the Membership was selected from scientists who:

> -- are widely recognized for their credibility and integrity; and
> -- have substantial experience in the use of scientific and technical information from a broad range of disciplines relevant to the development of sound environmental policy.

Members of the Board are:

Dr. Kenneth Arrow, Nobel Laureate and Professor of Economics at Stanford University;

Dr. John Bailar, member of the faculty of Epidemiology and Biostatistics at McGill University; Science Advisor to the U. S. Office of Disease Prevention and Health Promotion, Department of Health and Human Services; statistical consultant for the *New England Journal of Medicine*;

Dr. John Gordon, Dean of the School of Forestry and Environmental Studies at Yale University;

Dr. Glenn Hilst, consultant in atmospheric sciences;

Dr. Simon Levin, Director of the Center for Environmental Research and Charles A. Alexander Professor of Biology in the Section of Ecology and Systematics at Cornell University;

Dr. Thomas Malone, Professor Emeritus at St. Joseph's College, Connecticut, and former president, Sigma Xi;

Dr. William Nierenberg, Director Emeritus at the Scripps Institute of Oceanography in La Jolla, California;

Dr. Milton Russell, Professor of Economics and Senior Fellow of the Energy, Environment and Resources Center, University of Tennessee, Knoxville; and Collaborating Scientist, Oak Ridge National Laboratory;

Dr. Chauncey Starr, President Emeritus of the Electric Power Research Institute;

Dr. John Tukey, Donner Professor of Science Emeritus and Professor of Statistics Emeritus at Princeton University; and former Associate Executive Director, Research, Bell Laboratories.

The Board held its first meeting on September 6 and 7, 1989. It will meet at least quarterly and will participate actively in the International Conference on the Assessment in February. The major function of the Board will be to oversee the process by which the scientific findings of this enormous research undertaking are brought to the point where they can be made accessible to decision makers, other scientists and concerned citizens. Obviously, its major task will be to see that this process is undertaken in such a way that the results of this enterprise measure up to the highest standards of scientific integrity. In addition, we will also be especially mindful of the Joint Chair's mandate to assure the "...quality, scientific integrity, credibility, and practicality..." of the Assessment and of the Lay Summaries that flow from this work.

It is not part of the Board's mandate to undertake a full-scale review of the science that lies beneath each finding. In any event, there is insufficient time for its members to accomplish such a task, and the range of expertise present on the Board, while broad, clearly does not encompass the myriad specialties that such an undertaking would entail. It will, nevertheless scrupulously examine the several peer review processes that are to be followed. It will seek to assure that the canons of scientific impartially are faithfully applied. It will encourage scientific and technological consensus to the greatest degree possible, and endeavor to insure a fair reporting of all sides of issues when no adequate consensus can be reached.

I wish to stress that the Board's mandate is consistent with that which we understand to be that of NAPAP itself: to develop, assemble and evaluate the science and technology associated with acidic deposition processes and effects, and not to concern itself with the policy decisions that may flow from it. Obviously, members of the Board may have personal opinions on policy issues that they may wish to express as the decision process unfolds. Such opinions, however, will not be the province of the Board nor of its members as they serve in that capacity.

The Board has undertaken this role with enthusiasm because its members recognize the inherent importance of the acidic deposition issue to this and other nations. They are also aware that it is of great importance that the NAPAP enterprise meet, and be seen to meet, the highest standards of objectivity and scientific rigor so that its findings can be used with confidence to inform the decisions that follow. Further, the Board is also mindful that other issues of similar import and with similar demands on a broad array of scientific disciplines and Agencies of government exist and will arise in the future. Finally, successful completion of this complex process will demonstrate that science can be marshalled on an interagency basis to assist the government in making such decisions. Therefore, the Board agrees wholeheartedly with Administrator Reilly that "...these activities will help guide future assessments of other major domestic and international environmental concerns." The importance of the NAPAP process reaches beyond the acid deposition issue, and goes to the heart of the role of science and technology in support of national objectives.

The Board believes that both the Joint Chairs and the Director of NAPAP, Dr. James R. Mahoney, deserve the highest commendation for taking the so far highly unusual step of creating a body of independent scientists to oversee the culmination of this ten year interagency effort. In doing so they have voluntarily created a body with the mandate to review actions as they take place, and to provide advice and counsel at a time when they can be most effective. Because of their initiative, the process by which the scientific findings are pulled together in a final assessment can be monitored as it proceeds, and any recognizable problems or concerns addressed before the findings themselves become enmeshed in the final decision process. This "real time" review means that issues can be surfaced before the final assessment is published and becomes enshrined in the public mind.

For reasons that I have given above I do not believe that as Chairman of the Oversight Review Board it is appropriate for me to accept your invitation to "...address the overall scientific foundations for today's understanding of acid deposition..." Moreover, my own expertise does not equip me to offer a personal, independent assessment. I am prepared, however, to address the second part of your request and comment on the "... potential use of continued data collection

after the mandate of NAPAP expires in 1990." I stress, however, that this issue has not been formally considered by the Board as a whole, though I have no reason to believe that its members would disagree with the broad substance of what I have to say. Thus the following views do not represent a considered position taken by the Board.

The NAPAP research program is entering its tenth year, and it builds upon focused research that antedates it at least a decade. It is understandable that the reaction would be, "Surely, we now know enough!" And, indeed, at the conclusion of NAPAP we will know a very great deal. The information returns to the Nation's investment are and will be very large. Decisions taken can be far better informed than they would have been even a few years ago. Unfortunately, though, the issues surrounding acid precipitation and its effects are exceedingly complex. Some of the processes at work have very long lag times, and some of the effects may be sufficiently subtle as to require long term monitoring to even discern, much less to quantify. Consequently, acid precipitation research is a process of unfolding answers and gradual refinement of hypotheses, some of which may prove to be wrong. Brief reflection on the past ten years offers examples of positions confidently held that have been overturned by research, and there is no reason to believe that all the truth will be evident at the end of 1990. Science simply does not happen that way.

By no means am I suggesting that decisions be delayed for interminable added rounds of research. What I am suggesting, however, is that even after decisions have been made there will be a continuing need for further work to refine what we think we know now, and to test our hypotheses against a natural world that does not conveniently respond to a policy-driven calendar. Therefore, I suggest that the sunset of NAPAP should not be allowed to close this chapter of cooperation and research; a continued effort at basic and applied science will be necessary. I invite the Committee's attention to how to accomplish this longer-run research mission, even as it grapples with what is to be done now.

Another matter is of even more immediate concern. That matter is assuring the capacity to monitor and interpret the effects of whatever policy is established at the close of NAPAP. There is a natural tendency to move on to other matters after a national policy is established. This course will be even more appealing to those who have participated in the long and sometimes contentious national debate over acid precipitation. In this case, however, following that tendency would be regrettable. One can confidently predict that mid-course adjustments in any policy might prove advisable even if there is no change in basic scientific understanding. Without an ongoing monitoring and assessment program, however, opportunities for knowing about the need for such adjustments are foregone, and the Nation could be worse off for it. Therefore, some institutional mechanism for ongoing attention to acid deposition seems to me appropriate, preferably one which continues to call on the expertise and cooperation of the diverse Agencies involved in the research to date.

Finally, an enormous body of information and data has been gathered in this massive interagency undertaking. At present, the close coordination of the interagency effort under NAPAP assures that its disparate parts are available to all those involved. Once NAPAP disappears and interagency work groups disband, however, institutional cohesion and institutional memory will predictably dissipate. For example, data bases will become in fact as well as in form the responsibility solely of the Agency that developed them. Their maintenance will understandably

depend on the degree to which they further the mission of that Agency. Some will live and be available for further use, but others will be allowed to wither and ultimately disappear or become dysfunctional. That means that evidence for the possible mid-course corrections referenced above may be unavailable when needed, or else require major new expenditures to collect. More immediately, implementation of any policy will require access to such information. If it is scattered among Agencies it will be difficult to assemble and use effectively.

For all these reasons I believe the Committee is far-sighted and wise even at this early stage to invite consideration of what happens after NAPAP goes out of business. My own opinion is that the end of NAPAP should mark only the first stage of a continuing process. The Nation will get full measure of return for its past investment only if thought is given soon to arrangements for its exploitation in the future.

In conclusion, Mr. Chairman, the Oversight Review Board welcomes this opportunity to explain its role to the Committee. As is consistent with its mandate, it will be pleased to cooperate with the Congress as such cooperation is requested. Its major task, however, is to provide advice and counsel to the Joint Chairs and to the Director of NAPAP on matters of science. Its mandate and goal is to assure to the extent possible that the information available to the public is as complete, as reliable and as usable as possible. This will, of course, require in some instances careful explanation of what is still uncertain. Speaking for myself and for other members of the Board, it is our firm intent to fulfill that mandate.

I will be pleased to answer any questions.

Thank you.

RECEIVED
AUG 10 1989

**NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM**

722 JACKSON PLACE, N.W.
WASHINGTON, D.C. 20503
202/395-5771

Dr. Milton Russell
327 South Stadium Hall
University of Tennessee
Knoxville, Tennessee 37996

Dear Milton:

After more than eight years of research and technology evaluation activities within the ten year program mandated by Congress, the National Acid Precipitation Assessment Program (NAPAP) is preparing an extensive series of assessment reports to the President and Congress. These reports will document the NAPAP findings on the causes and effects of acidic deposition, combined with analyses of options for control of its effects. The NAPAP Joint Chairs Council (members listed on page 3) is establishing an Oversight Review Board to provide counsel on the effectiveness of NAPAP's approach to evaluating and reporting the broad range of information developed during the program.

We are writing to solicit your membership on the NAPAP Oversight Review Board. The Board will consist of ten distinguished scientists who:

-- are widely recognized for their credibility and integrity; and

-- have substantial experience in the use of scientific and technical information from a broad range of disciplines relevant to the development of sound environmental policy.

The principal responsibilities of the Oversight Review Board are to provide advice to NAPAP Management and the Joint Chairs Council regarding the quality, scientific integrity, credibility, and practicality of the many different parts of the NAPAP Final Assessment. This will require evaluation of NAPAP's approach to creating, reviewing, and publishing the following parts of the Final Assessment:

-- State of Science/Technology Reports to be published as review drafts in November 1989 and in final versions in July 1990;

-- Lay Summaries of the State of Science/Technology Reports to be published in 1990; and

-- The Integrated Assessment to be published in September 1990.

The Board will have an initial two-day meeting, and will then meet for approximately one day each three months until completion of NAPAP activities in December 1990. We hope that Board members will be able to attend the NAPAP International Conference at Hilton Head Island, South Carolina on February 11-16, 1990 (brochure enclosed). This Conference has been designed to provide critique on State of Science and Technology Reports which provide the foundation for NAPAP's Integrated Assessment. Board members will be reimbursed for travel and related expenses associated with their services.

The Board is encouraged to work closely in reviewing its findings with NAPAP Management and to provide recommendations to the Joint Chairs Council as appropriate. A written summary of the Board's findings and recommendations about NAPAP's assessment approach will be requested at the completion of the Final Assessment.

We believe that members of the Oversight Review Board will have a unique opportunity to assist NAPAP in its evaluation of this important environmental issue, and that these activities will help guide future assessments of other major domestic and international environmental concerns.

You will be contacted by the NAPAP Office of the Director to review any questions you may have and to confirm your response to this request. We appreciate your willingness to participate in this essential component of NAPAP's activities.

Sincerely yours,

William K. Reilly

William K. Reilly, Administrator
Environmental Protection Agency
and Chairman of the NAPAP
Joint Chairs Council

Enclosures

TESTIMONY

Subcommittee on Environmental Protection
October 5, 1989

Walter A. Kretser

My name is Walter A. Kretser. I am a research scientist with the Department of Environmental Conservation in New York State. I became involved with acidification issues in 1980 when I was project leader for the Survey and Inventory Unit in the Bureau of Fisheries. At that time, New York State Division of Fish and Wildlife staff were involved in conducting synoptic survey investigations to determine the extent of acidification of lakes and ponds located in the Adirondack region of New York. As unit leader, I was responsible for coordinating and implementing field and laboratory tasks necessary to collect and analyze surface water samples to evaluate the chemical status of lakes and ponds. From 1977 through 1982 a total of 1047 waters were examined for pH, acid neutralizing capacity and conductivity. The results of this preliminary effort indicated that acidification was a problem and that approximately 19 percent of the waters analyzed had surface pH values below 5.0 and most likely could not sustain fish populations. The results of this effort confirmed the results of work conducted by investigators from Cornell University in 1976 which indicated that many of the high elevation waters were acidified and 90 percent of the 214 waters investigated did not contain fish populations. Unfortunately, the Cornell Studies, the New York State Department of Environmental Conservation synoptic survey data and previous survey data that included the extensive biological surveys of the Adirondack watersheds (1929 through 1934) were considered inadequate to answer questions relating to the acid precipitation phenomenon. Documented losses of fish populations and speculation as to the cause of such losses could not be adequately assessed even with this extensive amount of information. The limited number of chemical parameters and the lack of extensive current biological and physical data collected from each water utilizing standardized methodologies limited the usefulness of existing data. In addition, fisheries surveys were conducted on less than 11 percent of the Adirondack waters during the 1974 to 1983 time frame. More than 45 percent of the lakes and ponds in the Adirondack region were never surveyed.

Recognizing the need for a much expanded and standardized data base, environmental specialists from the NYSDEC and the Empire State Electric Energy Research Corporation (ESEERCO) developed a cooperative project aimed

at expediting the acquisition of fisheries and water chemistry data for at least 1450 Adirondack ponded waters over a four year period beginning in 1984. To accomplish this effort, the Adirondack Lakes Survey Corporation was formed to specifically conduct these operations. Under this arrangement, a board of directors, a management committee and a staff of 25 professional biologists, chemists and technicians were assembled to conduct this joint $5.3 million project. I was assigned as the project manager of this effort.

The goal of the Adirondack Lakes Survey Corporation was to:

- Complete comprehensive fish and chemical surveys of lakes and ponds within the Adirondack ecological zone to provide an accurate, up-to-date, comprehensive data base for making current fisheries management decisions and providing a basis for assessing environmental impacts and associated trends.

The objectives were to annually determine the status of fish populations and water chemistry in at least 400 ponded waters located in three major watersheds during the first three years and at least 250 waters in the two remaining watersheds during the 1987 field year.

Five field teams consisting of three biologists each focused sampling efforts on the five major watersheds originating within the Adirondack ecological zone representing approximately 6.5 million acres. Within this land mass, 2759+ individual lakes and ponds greater than one half acre in size, representing approximately 246,000 acres of surface water, were identified on USGS maps.

From 1984 through 1987, ALSC biologists completed surveys including spring or fall fisheries and chemical investigations, intensive midsummer chemical sampling and bathymetric mapping on 1469 waters or 53 percent of the total number of waters in the region of study. I might point out that this compares to 149 Adirondack waters (5.0%) sampled as part of the NAPAP Eastern Lakes Survey (ELS) program conducted in 1984. The waters surveyed by the ALSC ranged in size from one-half acre to 708 acres representing 58,956 acres of surface area. Approximately 41 percent of the waters surveyed were equal to or less than ten acres in size. Forty-seven percent of all waters identified in this region are in this size class. The ELS program did not consider lakes in this size category as part of the total population of waters in the region.

Survey waters were selected utilizing a modified random selection process during the first three years of the project and a total random selection process in 1987 when fewer

waters were selected for survey.

Surveyed waters ranged in elevation from 137 m to 1129 m. More than 50 percent of the waters were located at elevations greater than 500 m above sea level.

Water samples were collected from each water at least two times; one surface sample was collected during the spring or fall biological survey effort and one or two samples were collected during the intensive summer chemistry effort depending on temperature stratification. More than 4200 water samples were analyzed for 24 different chemical parameters.

The results of these analyses indicated that air equilibrated pH values for surface waters ranged from 3.9 to 8.9. A total of 352 waters (24%) representing 8.4 percent of the surface area surveyed had pH values less than or equal to 5.0 or were considered critically acidified based on the New York State lake classification system. An additional 269 waters had pH values from 5.1 to 6.0, falling into the "endangered" category under this same classification.

Acid neutralizing capacity (ANC) values using the Gran's plot technique ranged from -134.0 ueq/1 to 2671 ueq/1 with a median value of 47.4 ueq/1. Negative ANC values were found in 27 percent of the waters while another 309 or 21 percent had values between zero and 40 ueq/1. Fish were not found in 267 waters with negative ANC values. Slightly under 93 percent of the fishless waters had ANC values below 40.0 ueq/1.

Fish populations were present in 1123 or 76 percent of the waters surveyed. Fish were not captured in 346 waters. Of the 346 waters, 46 were classified as true bogs.

All data collected from 1984 through 1987 was compiled in 18 separate volumes each containing individual pond data consisting of sixteen record types. The entire data base was summarized in a detailed summary document entitled "An Evaluation of Fish Communities and Water Chemistry" released in February 1989. In addition, the ALSC extended a contract to a team of nationally recognized scientists currently involved with acidification studies to interpret the data that has been collected during this intensive effort. The ALSC data plus other data collected from research projects conducted in the Adirondack region since the 1970's will provide the scientific community with a much greater understanding of acidification processes in this region. The interpretive report based primarily on this exhaustive data set is to be released by the end of October 1989. We are currently working with NAPAP staff to make certain that the results of this research are included in the state-of-science draft scheduled for public review in November. If

the effort to get this information into the November draft is not successful, we believe that it must be included in the final NAPAP assessment due in 1990. Failure to include this significant set of data and interpretation may reduce the credibility of the final NAPAP Assessment document in regard to aquatic effects.

In my opinion, acidification is a serious problem in the Adirondack region of New York, particularly in the higher elevation areas over 610 m located primarily in the southwestern part of the region. This is an area that is dominated by well weathered igneous and metamorphic rocks associated with thin, shallow infertile soils. Ongoing and recently completed acidification studies have suggested that sources of acidity can be from naturally occurring processes as well as from atmospheric deposition. Because the southwestern area of the Adirondacks is located downwind from identified sources of pollution and receives the highest sulfate and nitrate loading in the state, it is essential to determine the relative importance of acidity sources. An attempt to identify the relative importance and contributions from these sources is currently underway by the ALSC interpretive team.

Acidification problems in the Adirondacks were first brought into the public limelight when large numbers of waters with apparent losses of fish populations caused the scientific community to focus on "acid precipitation." Waters devoid of fish populations can be the result of many factors including loss of spawning sites through beaver activity or siltation, lack of favorable oxygen and/or temperature conditions, change in fish management strategies as well as adverse chemical conditions. However, it is clear from the ALSC data that a strong correlation exists between low pH waters and waters without fish. Existing long-term trend data relating to losses of fish populations as a result of chemical change is weak at best. Work to date has looked at fish presence and absence but has not focused on reductions of biomass and changes in population structure and diversity under changing chemical conditions.

It is also my opinion that a commitment to long-term monitoring programs that include a strong biological component is essential; otherwise, trend data will not exist. Reduced levels of atmospheric emissions must be measured against changes in the biotic communities in order to evaluate emission reduction strategies and provide a basis for decision making. Monitoring should be geared to evaluate the effects within different categories of waters. Each water is unique and is likely to respond differently to changes in atmospheric inputs. Waters influenced primarily by naturally acidic inputs may not respond to any level of emission reductions while others may respond significantly and quickly. Again, we expect that the interpretation of the

extensive ALSC data set will specifically address these issues.

The Episodic Response Program that we are currently involved in with EPA appears extremely important in that biological and chemical responses to atmospheric events can be observed and documented quickly. This program should be linked to or become part of a long-term monitoring program.

Finally, I would like to state that the work conducted by the Adirondack Lakes Survey Corporation focused on compiling a large set of information on a large number of lakes over a short time span. The results of this effort provide us with a snap shot in time that can be used as a baseline for evaluating future environmental changes, whether anthropogenic or natural in origin. The results of this effort will be invaluable to future generations that must continue to monitor and manage aquatic systems in this region.

TESTIMONY
FOR
THE SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION
THE UNITED STATES SENATE

October 5, 1989

by

G. M. HIDY
ELECTRIC POWER RESEARCH INSTITUTE
PALO ALTO, CA 94303

Ladies and Gentlemen:

My name is George M. Hidy. I represent the Electric Power Research Institute, a non-profit research planning and management institution sponsored by electric utilities in the United States. As EPRI's Vice President, Environment Division, I will summarize EPRI's views on the status of scientific knowledge about the origins and effects of acid deposition, and the implications of the knowledge for proposed emissions control legislation of sulphur and nitrogen oxides ($SO_x$ and $NO_x$). I will comment on the research results from our program, in addition to the results of the National Acid Precipitation Assessment Program (NAPAP). To complete my report, I will note the needs for research that should continue beyond the NAPAP expiration in 1990.

For the record, I have been actively involved in air pollution and acid deposition research since long before 1974. I have served the federal government as a member of the Environmental Protection Agency's (EPA) Science Advisory Board since 1980, and as a reviewer of the NAPAP research, management and organization. I have also served on National Academy of Sciences committees examining the state of knowledge on acid deposition.

1. Summary

First, let me summarize the points that I will make today:

a. Research during the past decade on acid deposition has provided critical information for decision makers, either in new definition and discovery, or in refinement of earlier knowledge. Much of this information comes from the National Acid Precipitation Assessment Program (NAPAP), and its cooperative activities with other organizations.

b. The research has confirmed certain effects associated with man-made sulfur and nitrogen oxide emissions ($SO_x$ and $NO_x$). At atmospheric levels, these efforts focus on changes in surface water chemistry, deterioration of materials, and visibility impairment.

c. None of the identified effects is geographically widespread, or represent rapid environmental deterioration. Therefore, there is time for a considered, well planned strategy to reduce $SO_x$ and $NO_x$ emissions, if deemed desirable, to insure against possible adverse environmental change in the long term.

   -- Timing is important to take maximum advantage of new technology currently undergoing demonstration.

   -- A selective control strategy to reduce exposure at sensitive receptors, while minimizing cost, is important for decision making. Source-receptor modeling could be used to facilitate this requirement.

d. Research indicates that the currently proposed strategy for reduction in $SO_x$ and $NO_x$ emissions may not result in meaningful environmental improvement of lakes and forests, or material damage reduction over the next half century.

e. The environmental benefits are perceived to be very limited compared with the estimated high costs of proposed emission controls.

   -- An environmental benefit vs. emission reduction cost analysis is essential to support the proposal for a 10-million ton per year $SO_x$ emission reduction.

f. If low alkalinity lakes are the focus of concern, liming treatment offers one important cost-effective, environmentally benign alternative that will predictably improve the lake acidity status.

g. Expiration of NAPAP in 1990 should not inhibit planning and execution of continuing research on acid deposition or related issues.

   -- EPRI considers that health effects of $SO_x$ and $NO_x$, forest response to $SO_x$ and $NO_x$ exposure, and mathematical determination of source-receptor relations to be high priority for a national research agenda.

h. To insure that a measurable verification of modeling and predictive methods is derived as a part of a national emissions control program, long-term environmental monitoring should be undertaken.

   -- Monitoring would be desirable to track chemical deposition, surface water chemistry, and soil-forest ecosystem characteristics for verification of long-term model predictions.

2. Current Scientific Knowledge

The United States national effort to investigate the causes and environmental effects of acid deposition has been very substantial. The NAPAP program has invested nearly $0.5 billion in its nine-year lifetime; EPRI has invested more than $80 million since 1980 in these scientific investigations. EPRI also has contributed more than $200 million to the development and demonstration of new, low emission technology during that period. The electric utility industry, as members of EPRI, made this investment because of their perception in the late 70's that the existing information was too sparse for good decision making on acid deposition, and led to exaggerated accounts of environmental effects. The reports of widespread and sudden environmental stress required careful investigation. Simultaneously, there was a need for early investigation of technological alternatives for reducing $SO_x$ and $NO_x$ emissions, should this be necessary.

The research to date has placed perspective on acid deposition through a greatly improved body of knowledge. A summary of EPRI's research results to date is included in this testimony (Attachment A). (Attachment A has been retained in committee files.)

EPRI's research has been closely coordinated with federal government efforts before and after the inception of NAPAP. Our work has been designed carefully to sponsor the research community for complementary studies to NAPAP, and to support important projects beyond the resources of either organization alone. Both NAPAP and EPRI have relied on experts in the universities, the national laboratories and the private sector for the required research.

The evolution of knowledge on subjects relevant to $SO_x$ and $NO_x$ in the environment, and in acid deposition are summarized in Attachment B. In this table, there is a list of relevant topics that have been discussed in public debates along with key results obtained from research since 1980. I have qualitatively classified the results into two categories -- refinement of knowledge, and new definition and discovery. Refinement refers to a marginal extension of information over previous work; new definitions or discovery indicate a very

substantial increase in information over an earlier base. This is my judgment, but the classification may assist you in weighing the new knowledge against the established base in 1980. As you will note, there have been substantial contributions to knowledge in ecological and biological effects, along with significant refinement in other areas, including the knowledge of origins and atmospheric processes leading to deposition exposure.

Experts have differed and will continue to differ on the interpretation of the scientific results. The results indicate that acid deposition is a legitimate but complex environmental concern. However, it is not possible to make a case for catastrophic environmental or health effects of acid deposition (see Attachment B). Note that adverse health effects have been a basis for Clean Air Act legislation since 1967. Adverse health effects have not been confirmed from acid sulfate at concentration levels currently found in the U.S. atmosphere. The adverse effects of $SO_2$ and $NO_2$ are under periodic review under the Clean Air Act. EPA's current evaluation highlights the ambiguity of "adversity" in laboratory generated responses. Natural ecosystems in the United States appear to be resilient to deposition exposure at current levels and perhaps higher levels in the past. Changes, if any, are geographically confined and slow to occur. In the case of both aquatic and terrestrial systems, the effects are marginal and very slow. Improvements resulting from emission reductions may not be measurable against a background of natural variations.

The debates on control strategy have relied on broad scale emission reductions without discrimination by major sources in effectiveness of emission control to protect selected, sensitive receptors. A large effort of research has focused on the major improvements in mathematical models to infer the relation between source emissions and receptor exposure. These improvements appear to have been achieved through the development and evaluation of the Regional Acid Deposition Model (RADM).

The calculations currently being completed in the RADM project give increased confidence that reliable estimates of the reduction on exposure from source emission controls of $SO_x$ and $NO_x$ and volatile organic compounds can be made. Examples are planned to be available with the 1990 NAPAP assessment. This means that calculations could be done by EPA to design an optimum, cost-effective control strategy for protection of sensitive receptors without legislating a potentially very costly but inefficient nationwide emission reduction program.

Much has been said about damage to lakes and fisheries from acid deposition. This is one of the more emotional aspects of acid deposition and is one of strongly differing opinions given the facts as we know them today. I would like to elaborate on the aquatic effects because of their significance in the debates. First, it is important to state the facts as concisely as possible. NAPAP and other research, including that of the the Adirondack Lake Survey Corporation (ALSC) and EPRI, have shown that only a small fraction of the sampled low alkalinity lakes are acid in the United States. Lake acidity and acidification depend strongly on the nature of the basin in which the lake resides.

The location of the small fraction of acid lakes is in the Northeast, the glaciated areas of Wisconsin and in northern Florida. The reasons for the acidity cannot be derived from the survey data since they were taken essentially at one time. The historical record of change in lakes and streams that might indicate acidification is very weak. The very careful lake analysis from the 1986 National Academy of Sciences study suggests that acidification can be traced to only a few lakes in the Adirondacks. Of this historical sample, only a few percent of the acidification can be explained by an atmospheric deposition mechanism alone. The historical information on streams is limited primarily to USGS results. Their work indicates sulfate change with $SO_2$ emission changes if the watershed soil is saturated with sulfate, but no such change where sulfate is retained in the soil. If there is sulfate retention, then loss of alkalinity is not expected.

The ALSC data suggest that up to 40% of the acidic lakes found in the Adirondacks have acidity dominated by naturally occurring organic acids and not mineral acid (sulfate or nitrate). The interpretation of the ALSC data suggests that the lake status will change very little over the next several decades because of the important role of organic constituents in affecting acidity levels.

There is simply no evidence of long-term lake acidification in the West, although a few transient acid changes have been reported in the alpine areas of Colorado and California. This situation exists, despite a projected substantial historical exposure from $SO_x$ and $NO_x$ emissions, for many decades in parts of the West.

Mathematical models have been developed through NAPAP and EPRI research that will predict the lake and fishery status given deposition levels, soils and watershed characteristics, as well as the rates of change in water chemistry. Aquatic models have been evaluated and tested; they have yielded estimates for lake change with change in deposition rates. The models may overpredict improvement for deposition reduction if dissolved organic acids are included. EPRI's limited calculations using the ILWAS model suggest no improvement for 50% reduction in sulfate deposition for Big Moose Lake, NY. Improvement was calculated only in an extreme case of high acidity (Woods Lake, NY) for a 50% reduction in sulfate deposition. This chemical improvement would still not result in fishery viability in this lake.

EPA has recently released the summary of a major water chemistry study, the Direct/Delayed Response Project (DDRP). The estimates reported in this project predict a slow decline or response (over a 10-20 year period, or more) in surface water status in the Northeast area with no emission changes, as well as with hypothetical reductions. In an area where no waters are currently acidic (the Southern Blue Ridge Province), the DDRP calculations again suggest very slow, and small change in status at current deposition levels or increased levels over 50 years. No calculations for decrease in emissions were reported. In my opinion, the DDRP results as reported

in its summary hardly warrant the inference of urgency in EPA's press release, "This study makes a compelling statement about the future effects of acid rain on water quality...The scientific data reinforce President Bush's proposal to reduce annual sulfur dioxide emissions by 10 million tons. ..."

The results are highly significant in that they do not provide a case for urgent action on emission controls without carefully sorting out the effectiveness of technological options. This in turn is of special concern since choices today for $SO_x$ and $NO_x$ control may affect decisions in the coming decade on other issues such as carbon dioxide ($CO_2$) emissions reduction.

At the very least, this committee, and other members of Congress should expect a clear statement from EPA and NAPAP about the environmental benefits predicted for the proposed national emission control levels and costs, and a clear scientific justification for the ten million ton $SO_2$ reduction proposed by the Administration. I believe that this is very important because the emission control costs rise rapidly above about a 6 million tons-per-year $SO_2$ reduction.

Past applications of EPRI's acid deposition risk analysis model (ADEPT) may be of interest here. ADEPT is designed to help decision-makers analyze the benefits and costs of alternative acid deposition policies. In the state of Washington, it was used to analyze the in-state costs and benefits of acid deposition controls. The study indicated that little environmental benefit would be gained from the imposition of controls to reduce sulfur dioxide emissions by 90%, while the costs of controls would exceed $1 billion. Similar results were found from ADEPT studies in Minnesota and Wisconsin. Given the scientific results on effects of acid deposition, there is reason to expect a similar answer for a national analysis.

The model has also been used to assess the risks from delaying a control decision until we have better information regarding several critical uncertainties. In an exploratory application of ADEPT by the Department of Energy in 1985, it was determined that the benefits from further research greatly outweighed those from a control strategy proposed by the Office of Technology Assessment. In my opinion, the same conclusions regarding benefits of control decisions would prevail if such analysis were conducted today.

3. Progress on Technological Solutions

As part of its NAPAP interactions, EPRI has worked closely with DOE and EPA to construct precise estimates, on a plant-by-plant basis, of future emission projections. These results have provided input into decisions about energy production scenarios expected for the coming years.

The nation is currently entering upon a period of rapid progress in technological development for emissions reduction, with a broad menu of technologies proceeding through pilot and demonstration stages towards commercial availability. These include both retrofit technologies applicable pre-, during- and post-combustion, and emerging technologies for repowering or new plant applications.

EPRI and the electric utility industry have invested over $2 billion to date on new technology for power production, and will spend more than $3 billion additional in what is now a national joint venture to accelerate its reliable commercial introduction.

The DOE's Clean Coal Technology Demonstration Program, with $1.5 billion of government funding offered to date, is a valuable example of government/industry cooperation. It is intended to accelerate clean coal technology development and the dates when these technologies will be available for reliable commercial use. EPRI is involved in 10 of the DOE CCT projects selected to date, and in 11 of the proposals recently submitted to DOE in the third round of the program.

The DOE program is still in its early stage as regards project implementation, and well over a decade will be required to allow some of the promising new retrofit technologies now in the pilot or early demonstration stages to reach maturity. A legislative timetable for future emissions reduction needs to take this into account if we are to build constructively upon this cooperative R&D and obtain cost-effective solutions to perceived environmental problems.

4. Role of NAPAP

NAPAP has been criticized frequently for being a relatively inefficient research enterprise. However, its primary measure of success is yet to come with the final assessment in 1990. The Interagency Task Force structure has had some difficulties, but has proven to be an effective oversight body to bring together efforts of several different government agencies to study aspects of acid deposition. The NAPAP management's apparent limitation in effectiveness is due in no small measure to the lack of budget authority given it, compared with its responsibility. NAPAP has served the nation well in bringing together a wide range of expertise to address the many facets of the acid deposition issue. NAPAP has been constructed as a relatively "open" entity that has exposed its work to a long and elaborate series of reviews and debates. It has attempted to assimilate a broad range of disparate views, and has worked toward scientific and technological consensus building. This approach in some ways has inhibited NAPAP leadership for timely results and has created inefficiency in its use of resources, but has preserved as much as possible an objective approach to the problem. Despite its perceived weaknesses, NAPAP has (a) contributed substantially to new or refined knowledge using methods that have taxed measurement and interpretive skills, (b) educated the public about the scientific problems of acid deposition and environmental protection, and (c) promoted major cooperative assessment studies with the public and private sectors and the Canadian government.

In my opinion, the important work of NAPAP should be completed and heard by the government and the general public as part of the decision process, consistent with the original NAPAP authorization. Finally, and most importantly, the NAPAP results should be used to insure that the investment in a major reduction program for $SO_x$ and $NO_x$ is well spent to achieve the environmental protection desired.

5. Future Research Needs

Despite the comprehensiveness of research planning, there remain questions that cannot be answered in the span of programs like NAPAP. Research on acid deposition remains incomplete in some areas, and further work needs to be contemplated. We at EPRI plan continuing studies, but with a reduced level of effort.

Included among the projected needs are:

a. Continued studies to determine the possible health effects of $SO_x$ and $NO_x$ at atmospheric concentrations.

b. Studies to complete the knowledge required to develop and verify the prediction capability of models for forest ecosystem response to $SO_x$ and $NO_x$ exposure, compared with their normal nutrient cycle, climate and disease variability.

c. Studies to complete the evaluation of regional scale deposition models to predict source-receptor relationships.

d. Continued studies to establish how changes in air quality affect visual impressions.

In addition, we believe that limited environmental, benchmark monitoring should continue for some time to provide a long-term record for model verification and to determine the deposition rates, and aquatic and terrestrial system actual vs. estimated improvements with emission reduction, should they be legislated. The expected environmental benefit (if any) should be verified progressively from

observation to insure confidence in our knowledge of change, and in our ability to provide such predictions. In this recommendation, we recognize that such measurements are likely to be required through at least 2010 to insure a coverage compatible with proposed schedules for emissions reduction. The appropriate entity to undertake this activity appears to be the federal government through EPA, DOA and the USGS.

These programs are key needs, but do not include the follow up of many other questions generated by the decade of acid deposition research. Given the experience of a periodic review process of the Clean Air Act, we anticipate similar reviews in the future. This will require increasingly elaborate information to address public concerns about possible environmental insults from acid deposition. Thus, continued research to reduce uncertainty in our knowledge will be in the public interest for some time to come.

6. Closing

In closing, ladies and gentlemen, it is worth noting that he U.S. public policy under the present Clean Air Act has shown great leadership since 1967 in protecting air quality. Looking toward the future, we should not discount our achievements to date at major public expense. We have now become a true world economic partner. The nation's future depends critically on how we balance the ideal of environmental protection with the realities of the world marketplace.

Thank you for this opportunity to share with you our research experience. I would be pleased to answer any of your questions.

SUMMARY OF EVALUATION OF SCIENTIFIC KNOWLEDGE BY TOPIC AREA
SINCE 1980

| TOPIC | REFINE | DEFINE/DISCOVER | RESULTS |
|---|---|---|---|
| 1. Human Health Effects | X (Direct) | X (Indirect) | No indirect effects confirmed; no direct effects are reported at atmospheric concentrations. |
| 2. Aquatic Effects | | X | Survey shows acid lakes a minor fraction of total in certain regions; origins of acidification not well documented; prediction of changes from models - change very slow, watershed critical. |
| --Mitigation (Liming) | | X | Liming is a cost-predictable effective mitigation with insignificant side effects. |
| 3. Forest Effects | | X | Forest deterioration identified in two areas, linkage with air pollution and acid deposition problematic. |
| 4. Agricultural Damage | X (Dry) | X (Wet) | No known acid deposition effect on yield of crops. Ozone effects widely known on some crops. |
| 5. Materials Damage | X | | Acid deposition is a factor in accelerating materials deterioration; damage assessment problematic because of replacement and maintenance patterns. |
| 6. Visibility Impairment | X | X | Visibility naturally affected strongly by humidity; air pollution is a factor in cities and in the East. Eastern conditions are improving. |
| 7. Emission Inventory | X | | Emission inventory quality greatly improved; much better knowledge of uncertainty; natural emissions better defined. |
| 8. Linkage between Emissions/Exposure (Transport and Deposition) | X | | Nature of source-receptor relations clarified in terms or air motion, chemical factors, much improved knowledge of dry and wet components. |
| 9. Risk Assessment (Cost/Benefit Evaluation) | | X | Methodology outlined and explored; limited by the fact that effects are minimal; calculations suggest very low benefit at high cost. |

ATTACHMENT B